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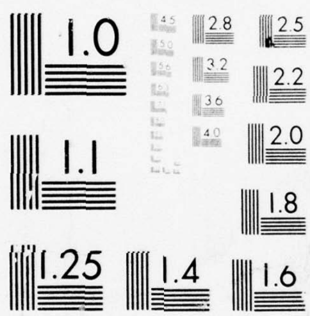

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Woods Hole Oceanographic Institution

W.H.O.I./BROWN CONDUCTIVITY, TEMPERATURE, AND DEPTH MICROPROFILER

by

N. L. Brown
and
G. K. Morrison

February 1978

TECHNICAL REPORT

Prepared for the Office of Naval Research under Contract N00014-66-C-0241; NR 083-004.

Approved for public release; distribution unlimited.

WOODS HOLE, MASSACHUSETTS 02543

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Approved for Distribution Earl E. Hays
Earl E. Hays, Chairman
Department of Ocean Engineering

ABSTRACT

A Conductivity, Temperature and Depth (CTD) profiler has been designed to make precise fine scale measurements of these physical parameters in the ocean. This CTD system consists of a shipboard Data Terminal deck unit and an underwater unit which provides continuous sampling of the three variables as it is lowered into the water. Additional sensors can be added to measure other variables; the most common is dissolved oxygen.

This report is a detailed description of the CTD System and includes the necessary documentation to operate and maintain the equipment.

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INTRODUCTION

The Conductivity, Temperature and Depth (CTD) profiler described here has been designed to make precise fine scale measurements of these physical parameters in the ocean. The CTD system consists of a shipboard Data Terminal deck unit and an underwater unit which provides continuous sampling of the three variables as it is lowered into the water. Additional sensors can be added to measure other variables; the most common is dissolved oxygen.

This report is a detailed description of the CTD System and includes the necessary documentation to operate and maintain the equipment.

Salinity can be derived from the pressure, temperature and electrical conductivity of a sample of sea water. With the CTD conductivity is measured with a miniature four electrode ceramic cell. Temperature is sensed by electronically combining the outputs of a high speed (30 millisecond) thermistor and a platinum resistance thermometer. This composite output has the excellent long term stability and linearity of the platinum probe with the rapid thermal response of the thermistor, independent of pressure effects and drifts in thermistor characteristics. Pressure is sensed by a strain gauge pressure transducer.

Data from the underwater unit is transmitted in real time to the shipboard data terminal through a single electrical conductor which is the core of the steel cable used to support the instrument in the

water. The data are in TELETYPE format using frequency shift key (FSK) modulation of a 5 and 10 kilohertz ac signal superimposed on the dc power supplied to the underwater unit through the same cable. This "audio" signal may be recorded directly on a good quality audio recorder for later processing.

The deck unit decodes the signal, provides digital data in both parallel and serial format for on-line computer processing and digital recording, and displays the variables in engineering units (decibars, degrees Celsius, and millimhos. There is also a digital to analog converter for real time plots using a two axis analog plotter.

The CTD is unique in that it provides the means for observing finestructure phenomena in both the temperature and salinity fields in the ocean at vertical scales of order centimeters. At the standard rate of 30 samples per second, an instrument lowered at about 75 meters per minute, for example, will give C, T, and D data averaged over about 1.5cm for each 5 centimeters of water providing a high resolution profile to full ocean depths (6000m) in about one and one-half hours.

SYSTEM DESCRIPTION

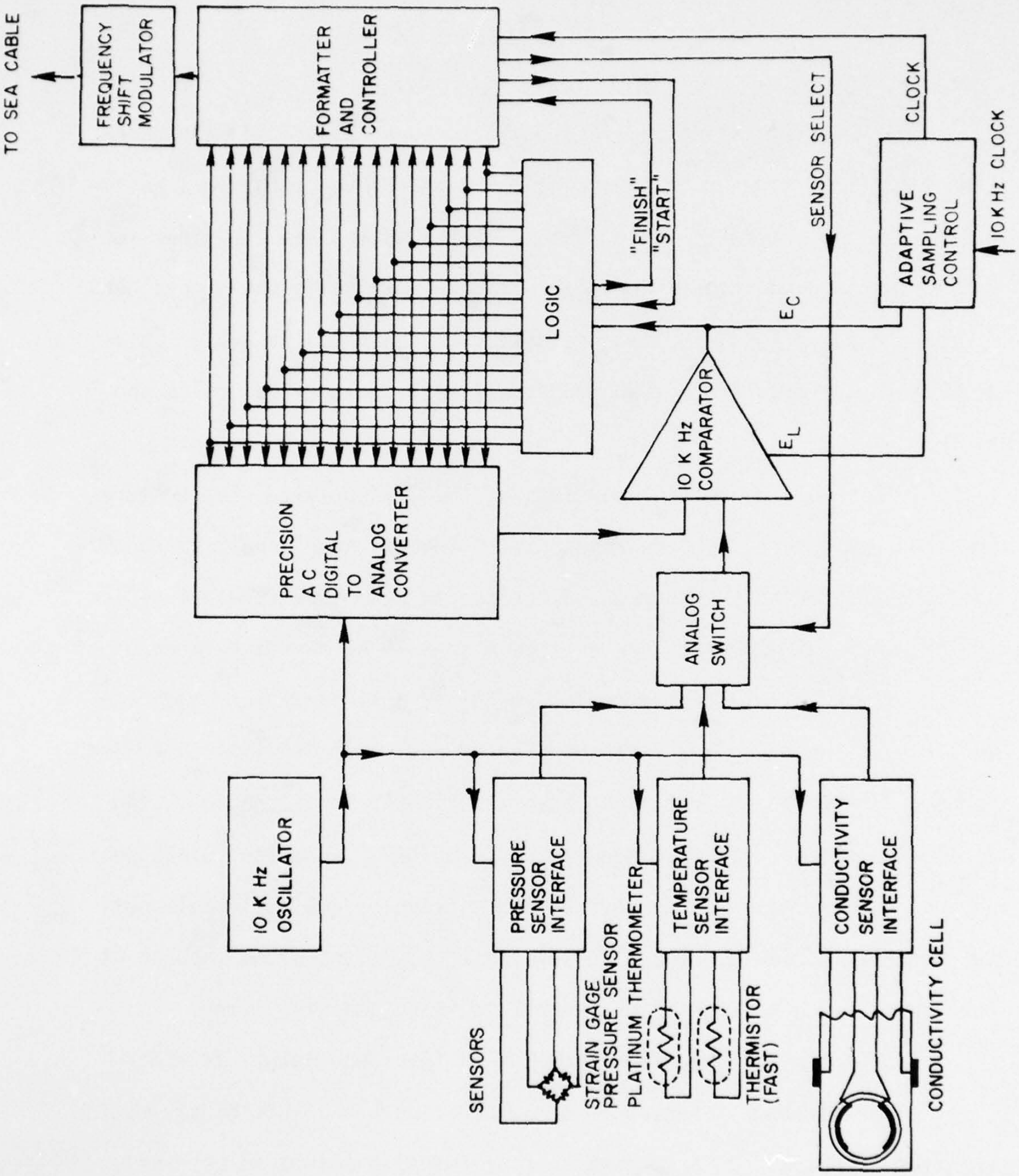
Underwater Unit

The CTD has two major assemblies, each subdivided into functional sections made up of modular circuit boards and mechanical assemblies. In the underwater unit these are the analog and digitizer sections plus some additional ancillary circuits including the Signal Generator and Power Supply voltage regulator. Figure 1.3 is a block diagram of the underwater unit showing these sections in relation to one another.

The analog section consists of the conductivity, temperature and pressure sensors and their associated interface or conditioning circuits. Consider each sensor and interface to be a four terminal device. If the two input terminals are excited with a 10 kilohertz reference voltage the amplitude of the output signal is a linear function of the variable as sensed by the corresponding transducer. The interface card for each sensor scales and linearizes the signals from zero to full scale in a special stable tuned feedback amplifier with the gain adjusted during calibration, and provides 500 millivolts RMS full scale output for each variable. These three conditioned signals then appear at the input of the analog switch for multiplexing and digitizing.

In the next section, each sensor interface output is electronically switched in sequence to the digitizer; a 16 bit binary ratio transformer which uses a successive approximation method to precisely determine the ratio of the output signal amplitude to the reference sig-

Fig. 1.3


TO SEA CABLE
FREQUENCY SHIFT MODULATOR
FORMATTER AND CONTROLLER
SENSOR SELECT
CLOCK
10 KHz CLOCK
ADAPTIVE SAMPLING CONTROL
LOGIC
"FINISH"
"START"
E_C
E_L
10 K Hz COMPARATOR
PRECISION A C DIGITAL TO ANALOG CONVERTER
ANALOG SWITCH
10 K Hz OSCILLATOR
PRESSURE SENSOR INTERFACE
TEMPERATURE SENSOR INTERFACE
CONDUCTIVITY SENSOR INTERFACE
SENSORS
STRAIN GAGE PRESSURE SENSOR
PLATINUM THERMOMETER
THERMISTOR (FAST)
CONDUCTIVITY CELL

nal voltage.

The AC Comparator, Digitizer Logic and D/A Converter form a loop which compares the output of the D/A with the sensor interface output bit by bit. Starting with the most significant, each bit is set high in turn, then reset or not depending on whether the D/A output is larger or smaller than the sensor output. The sequence continues until all 16 bits are tested. The Adaptive Sampling circuit controls the timing of the digitization and allows the comparator an appropriate recovery time after each test.

After all 16 switches have been sampled the digitizer sends a signal to indicate to the control circuitry that digitization is complete. In a standard system there are three digitization cycles in a data frame, one each for pressure, temperature and conductivity.

The Memory and Multiplexer circuit sequentially connects the interfaces to the digitizer and stores digitized words into buffer memory. The memory is required since the data from the previous frame is being clocked through the telemetry registers during digitization of the current frame. At the end of a frame the system waits for the next 31.25 hz clock pulse, after which the telemetry circuit is delayed for a few hundred microseconds while the buffer memory is dumped into the telemetry registers.

In the TTY formatting and FSK modulating card the serial data stream generated on the memory multiplexer board is serially shifted by the TTY gated clock. The data moves 8 bits at a time, then pauses while 2 "stop" bits and a "start" bit are mixed into the data stream. The

number of data bytes are counted and a continuous "high" or "one" state follows the data to complete the 32 ms. cycle or frame.

The data are shifted out of the TTY formatting circuit at 5000 bits/second into the FSK circuit where logic "ones" become two cycles of a 10 kilohertz sinewave and logic "zeros" become one cycle of a 5 kilohertz sinewave to be transmitted to the deck unit.

The signal generator board provides 10 kilohertz reference sine and square waves in phase, 10 kilohertz sine and square waves in quadrature ($\pm 90^{0}$) to the reference signals, and 20, 40 and 80 kilohertz signals used in some special systems as high frequency clocks; this board also generates the 31.25 hz timing clock.

The power supply regulates the dc from the deck unit via the cable and provides the +12 and + 6 volts dc necessary to power the Underwater Unit circuitry.

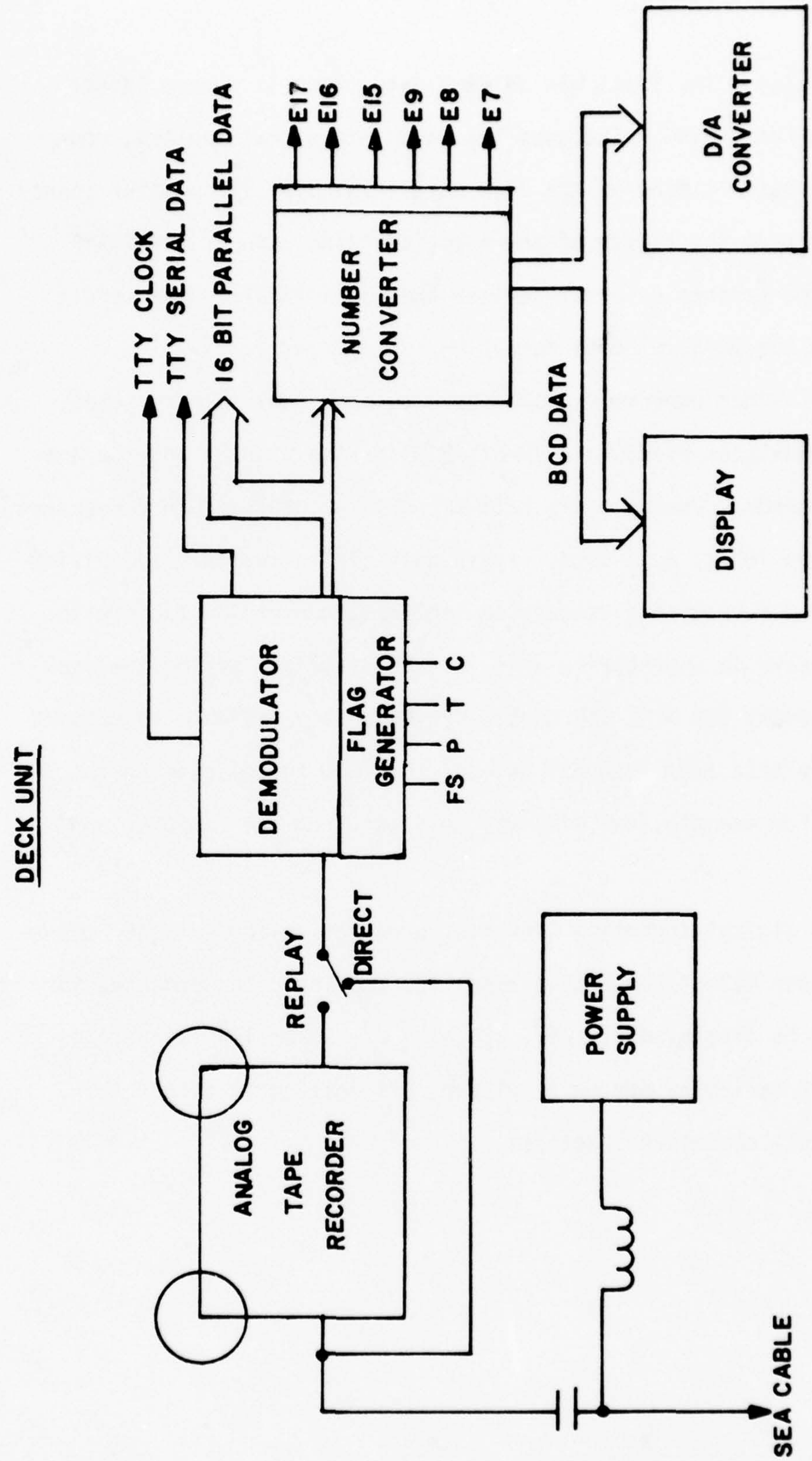
Deck Unit

The deck unit decodes the signal from the Underwater Unit and provides analog and digital CTD data in a variety of formats.

The deck unit block diagram is given in figure 1.3(3).

The Demodulator is a phase locked loop decoder which converts the frequency shift keyed data signal from the Underwater Unit into a normal high or low state data stream. These data are available both as 16 bit parallel and serial data in TTY format. The demodulator card includes a circuit which detects a continuous stream of eleven or more logic "ones" which occur at the end of each scan and from this generates the

Fig. 1.3(3)


DECK UNIT
ANALOG
TAPE
RECORDER
REPLAY
DIRECT
DEMODULATOR
FLAG
GENERATOR
FS
P
T
C
TTY CLOCK
TTY SERIAL DATA
16 BIT PARALLEL DATA
NUMBER
CONVERTER
E17
E16
E15
E9
E8
E7
BCD DATA
D/A
CONVERTER
DISPLAY
POWER
SUPPLY
SEA CABLE

FRAME SYNC pulse. The first bit in each data frame is a zero "start" bit, and the FRAME SYNC pulse goes low when this signal appears, controlling the basic timing of the deck unit. The BIT TIME counter counts clock pulses from the finish of the negative going edge of the FRAME SYNC pulse and strobes external devices when a particular data word is available at the parallel data output.

The number converter board converts the 16 bit binary output from the demodulator board into 20 bit BCD for the display and the analog output boards. During every half BIT TIME a complete BCD conversion is done on the 16 bit data word. It is possible to multiply and divide by powers of 2 during this process to implement conversion factors so the data appears in engineering units on the display. During the second half of every BIT TIME the Number Converter is available to convert 16 bit binary data from external devices into BCD for display on the deck unit. For example, salinity may be input from the computer and displayed.

The digital to analog converter provides analog outputs controlled by user selectable enable lines for scaling. Temperature, for example, may be displayed at $.25^{\circ}$, $.5^{\circ}$, 1°, 2°, 5° or 10° full scale. As many as 12 variables may be displayed, originating in either the underwater unit or external devices.

SPECIFICATIONS

MEASURED VARIABLES

Variable	Range	Accuracy	Resolution	Stability*
Pressure	0-320db	±0.5db	0.005db	
	0-650db	±1.0db	0.01 db	0.1%/month
	0-1600db	±1.6db	0.025db	
	0-3200db	±3.2db	0.05 db	
	0-6500db	±6.5db	0.1 db	
Temperature	-32 to +32°C	±0.005°C (-3 to +32°C)	.0005°C	.001°C/mo
Conductivity	1 to 65 mmho	±0.005 mmho	0.001 mmho	.003mmho/mo
Dissolved Oxygen Current (Option 01)	0 to 2 μA	± 2nA	0.5 nA	

*For detailed description of performance in the field, see Fofonoff, Hayes and Millard, 1974.

POWER REQUIREMENTS

Deck Unit

105 to 125 VAC 50 to 400Hz 200 watts
Fuses, Back panel 2 Amp, Acopian Supply (power down cable) 200mA

Underwater Unit

100mA constant current from a 50 volt supply in the data terminal. Voltage at underwater unit connector is 24 V ± 10% at 100ma.

DATA FORMAT

Data telemetry

Frequency shift key logic '1' is telemetred as two cycles of 10 kHz logic '0' is telemetred as one cycle of 5 kHz, 2 volts peak to peak max. (See Figure 3.1.12(2))

Pressure, Temperature and Conductivity are generated as sixteen bit binary numbers; for telemetry these are broken into 2 eight bit bytes each of which is telemetred in TTY format with a logic zero start bit and two logic one stop bits making an 11 bit word. They are telemetred least significant byte and least significant bit first in the following order.

FRAME SYNC
PRESSURE
PRESSURE
TEMPERATURE
TEMPERATURE
CONDUCTIVITY
CONDUCTIVITY
SIGNS
DISSOLVED OXYGEN CURRENT (Optional)
DISSOLVED OXYGEN CURRENT (Optional)
DISSOLVED OXYGEN TEMPERATURE (Optional)

SENSORS

1. Pressure

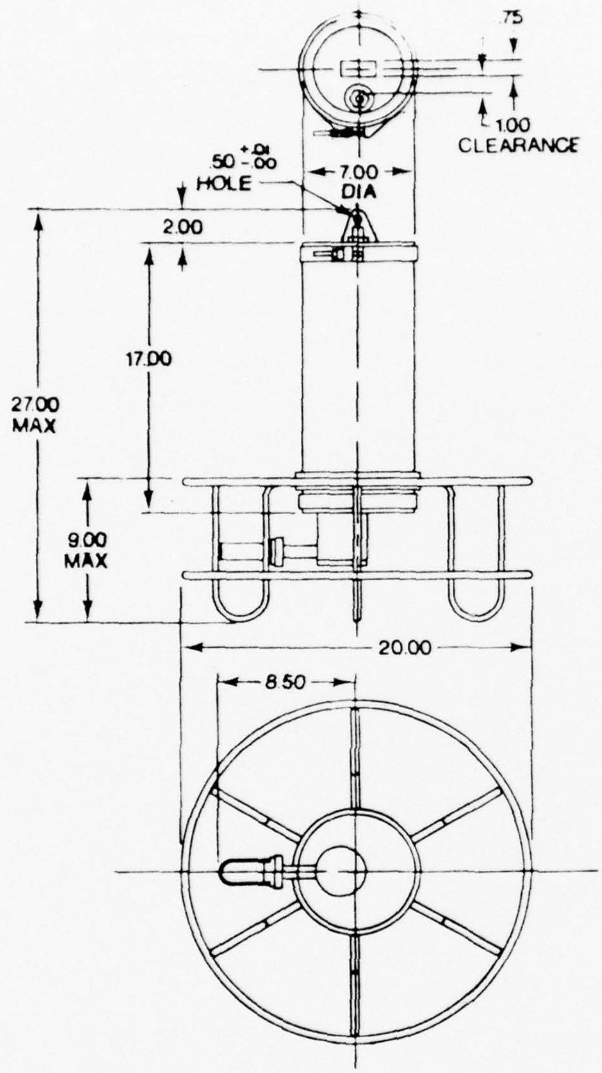
   Standard Controls Model 211-35-440;350Ω strain gauge bridge, tube type.

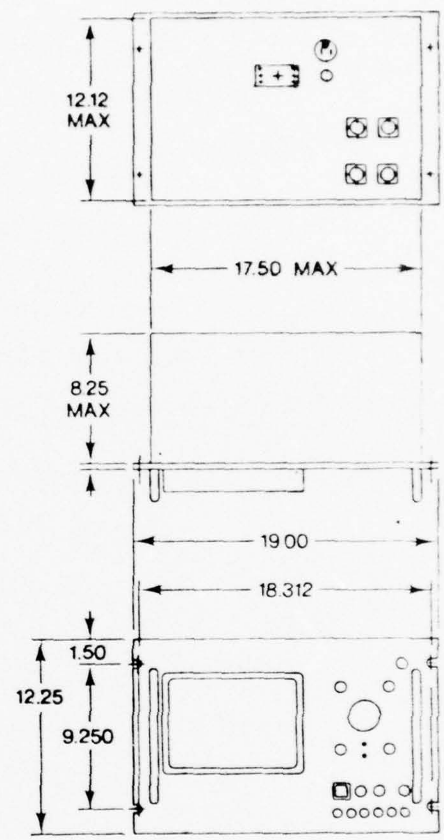
2. Temperature

   Platinum Thermometer Rosemount Model 171 BJ 200Ω @ 20°C (185.3Ω @ 0°C)
   Thermistor: Fenwal #GC32SM2 2000Ω @ 25°C nominal.

3. Conductivity

   Neil Brown Instruments #B10086 4 electrode cell .4cm x .4cm. x 3cm long. (see Section 3.1.4)





Dimensions in inches

UNDERWATER UNIT:

Weight in air: 95 pounds
Weight in water: 72 pounds
Material: 17-4 PH stainless steel
Maximum safe working pressure: 7500 decibars
Shock protection: rugged impact absorbing stainless steel guard frame

DECK UNIT:

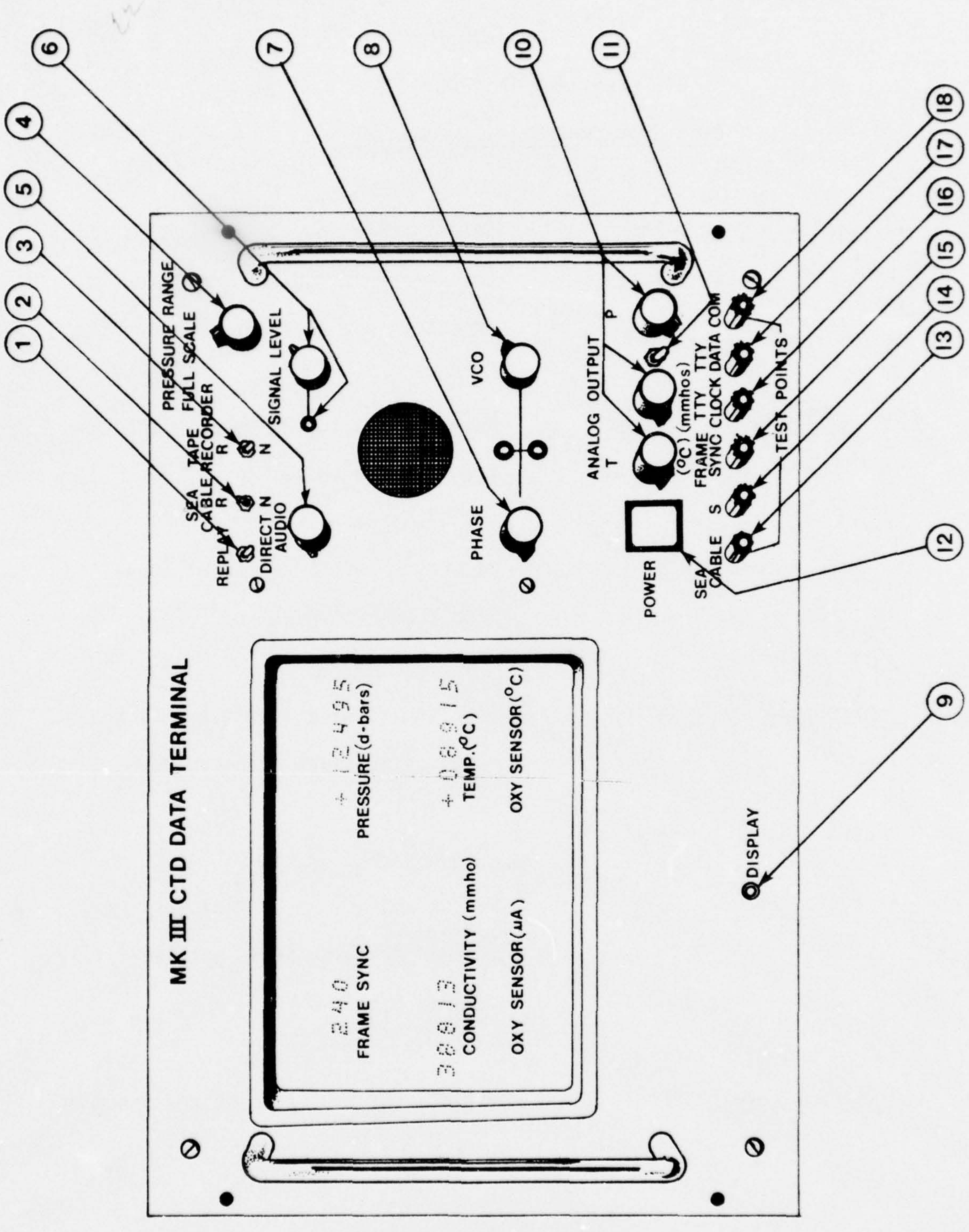
Weight: 25 pounds
Material: anodized aluminum

CTD OPERATING INSTRUCTIONS

Deck Unit Controls - See Fig. 2.1

(1)	Replay/Direct switch	Selects data source - Direct is from the sea cable connector, Replay is from the tape recorder connector.
(2)	Sea Cable R/N switch	Reversing switch to invert signal from the sea cable.
(3)	Tape Recorder R/N switch	Reversing switch to invert signal from tape recorder input.
(4)	Pressure Range switch	Sets the display to match Full Scale range of pressure transducer.
(5)	Audio control	Switch and volume control for the speaker allowing audio output of telemetered data.
(6)	Signal Level control	Adjusts the amplitude of the incoming data signal.
(7)	Phase switch	Compensates for the cable phase shift.

Fig. 2.1



MK III CTD DATA TERMINAL
240
FRAME SYNC
+12495
PRESSURE (d-bars)
380/3
CONDUCTIVITY (mmho)
+08915
TEMP. (°C)
OXY SENSOR (μA)
OXY SENSOR (°C)
DISPLAY
REPLAY
SEA CABLE
R
DIRECT N
TAPE RECORDER
R
N
AUDIO
PRESSURE RANGE FULL SCALE
SIGNAL LEVEL
PHASE
VCO
POWER
ANALOG OUTPUT
T
P
(°C) (mmhos)
SEA CABLE
S
FRAME SYNC
TTY CLOCK
TTY DATA
COM
TEST POINTS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

(8) V.C.O. control	Adjusts the frequency of the phase locked loop (PPL) in the demodulator.
(9) Display S/H switch	Freezes display (Hold) or allows it to change (Sample) at full data rate.
(10) Analog Output switches	
T C & P	Selects Full Scale Temperature, Conductivity and Pressure corresponding to the 0 to 10V dc analog signal at connector J17 on the back of the Deck Unit. T and C ranges are given on the front panel; refer to Fig. 2.1(2) for pressure ranges corresponding to the switch positions.
(11) S/H	Sample/Hold switch holds the analog output or enables sampling at full data rate.
(12) Power switch	Actuates ac and dc power to all circuits.

Test Points

(1) Sea Cable	Frequency Shift Keyed data stream at the input to the deck unit. Audio

Fig. 2.1(2)

Pressures corresponding to full scale analog output

Pressure transducer Range	0 - 13,000	0 - 6,500	0 - 3,200	0 - 1,600
Switch position				
1	100	50	25	12.5
2	200	100	50	25
3	400	200	100	50
4	800	400	200	100
5	1,000	500	250	125
6	2,000	1,000	500	250
7	4,000	2,000	1,000	500
8	8,000	4,000	2,000	1,000

N. B. All analog outputs are self paging, i.e. after full scale is reached origin is incremented to full scale on previous scan.

signal, 2 V p-p maximum.

(14) S — Digital Data stream in F.S.K. format after level adjustment.

(15) Frame Sync — Sync pulse, negative going edge is synchronized with start of a data frame for oscilloscope triggering, etc.

(16) TTY Clock — Clock running at 8 times the data rate; External input for teleprinter interface.

(17) TTY Data — Data stream in teletype format: open collector output (pull down resistor required if the TTY interface is not connected).

(18) Com. — Signal and DC common connection.

CTD Operation

1. Connect underwater unit to sea cable termination. (See section 2.2.1)
2. Connect end of sea cable from center of cable drum to slip ring rotor.
3. Connect slip ring stator to deck unit cable. (See Section 2.2.1)
4. Connect audio tape recorder output from deck unit to tape recorder if required.
5. Connect line cord to 105-125 V alternating current supply 47-400 Hz.
6. Set pressure range switch to range of sensor in use in underwater unit.
7. Set Direct/Replay switch to Direct.
8. Set Display switch to S.
9. Turn Phase & VCO control knobs fully counter-clockwise.
10. Actuate Power switch.
11. Vary Signal Level control until associated LED is dimly lighted.
12. Turn VCO control until two associated LEDS are on with equal light intensity.
13. Select the Phase switch position until the intensity of the LEDS is minimized.
14. When properly synchronized, the Frame Sync digital display word will be either "240" or "015" when Display switch is in the H mode. If not, 1) check for other positions of the VCO control that produce equal light level on the 2 LEDS, and check Frame Sync word.

2) If not synchronized,reverse Sea Cable R/N switch and repeat the procedure.

15. The digital display of Temperature and Pressure will now be reading ambient temperature and pressure and the CTD is ready to be lowered into the water. To record data on an audio recorder, adjust the signal level on the recorder and commence.

16. The audio recorder can be used as a back-up in case of malfunction of a digital data logger or computer processing system, or as a convenient way to store raw data for later processing. To replay from the Audio Recorder, switch Replay/Direct switch to Replay and proceed to set up Deck Unit starting at instruction Number 8.

ELECTRICAL CONNECTORS/CABLES

Underwater Unit

XSG-2-BCL connector.

Small pin   Signal and +DC

Large pin   Common

Mating Connector RMG-2-FS

Deck Unit

Sea Cable

A   Signal and +DC

B   Sea ground

Serial Data Out

A   12V TTY data (open collector

B   TTL Level TTY clock

C   TTL level TTY data

D   Common

Audio Tape Recorder

A   Output to tape recorder

B   Auxiliary input (high level)

C   N.C.

D   Common

E   Input from tape recorder

F

G   N. C.

H   N. C.

Analog Outputs (0 to 10 volt)

A Temperature

B Pressure

C Pressure common

D N.C.

E Conductivity common

F Conductivity

G Temperature common

H N.C.

Parallel Connections to Computer

See table in Section 5.2.7(3)

Cable Requirements

A single conductor armored cable is required such as Rochester type 1-H-255

SERVICE ACCESS TO UNDERWATER UNIT

Conductivity Cell and Thermistor Replacement

The sensor head is a subassembly that may be electrically disconnected from within the pressure housing and removed for servicing. The fast response thermistor, platinum thermometer and conductivity cell are mounted in the head in addition to the other elements of the thermometer bridge, (temperature transformer, T1 and Vishay resistor R_F.) To remove Thermistor or Conductivity Cell:

1) Lay the CTD Underwater Unit on its side with the sensor arm vertical and the sensors at the top.
2) Remove the "U" shaped sensor guard.
3) Carefully remove the two socket head screws that retain the sensor clamping plate.
4) Withdraw the clamping plate along with the conductivity cell and thermistor.
5) Exercising great care rotate the conductivity cell and thermistor until the clamping plate may be removed by passing the cell and thermistor through the slots.
6) Both the thermistor assembly and the conductivity cell connect to the leads via electrical connectors to facilitate rapid replacement. It will be necessary to either install a pre-calibrated card when changing a sensor or else to recalibrate the appropriate channel.
7) After cleaning and lightly greasing the 'O' rings with Parker

"Super 'O' Lube" the sensor head should be assembled in the reverse order, after purging with Freon gas.

Underwater Unit

To gain access to the underwater unit:

CAUTION: V-BAND CLAMP TORQUE MUST NOT EXCEED 60 INCH-POUNDS.

1) Remove the top V-band clamp.
2) Use a 3/8" rod through the mounting lug on the top cap as a handle and stand on the guard cage; remove the top cap with an even, steady pull. Be careful of the penetrator connector wiring on the inside.
3) Disconnect electrical connector on the inside of the top cap.
4) Place instrument on its side and remove the bottom V-band clamp.
5) Unseat bottom end cap seal by pulling firmly while grasping sensor arm, and remove bottom end cap and electronics chassis.
6) Remove card retainer by removing the six screws on the card rack.

To gain access to Sensor Head:

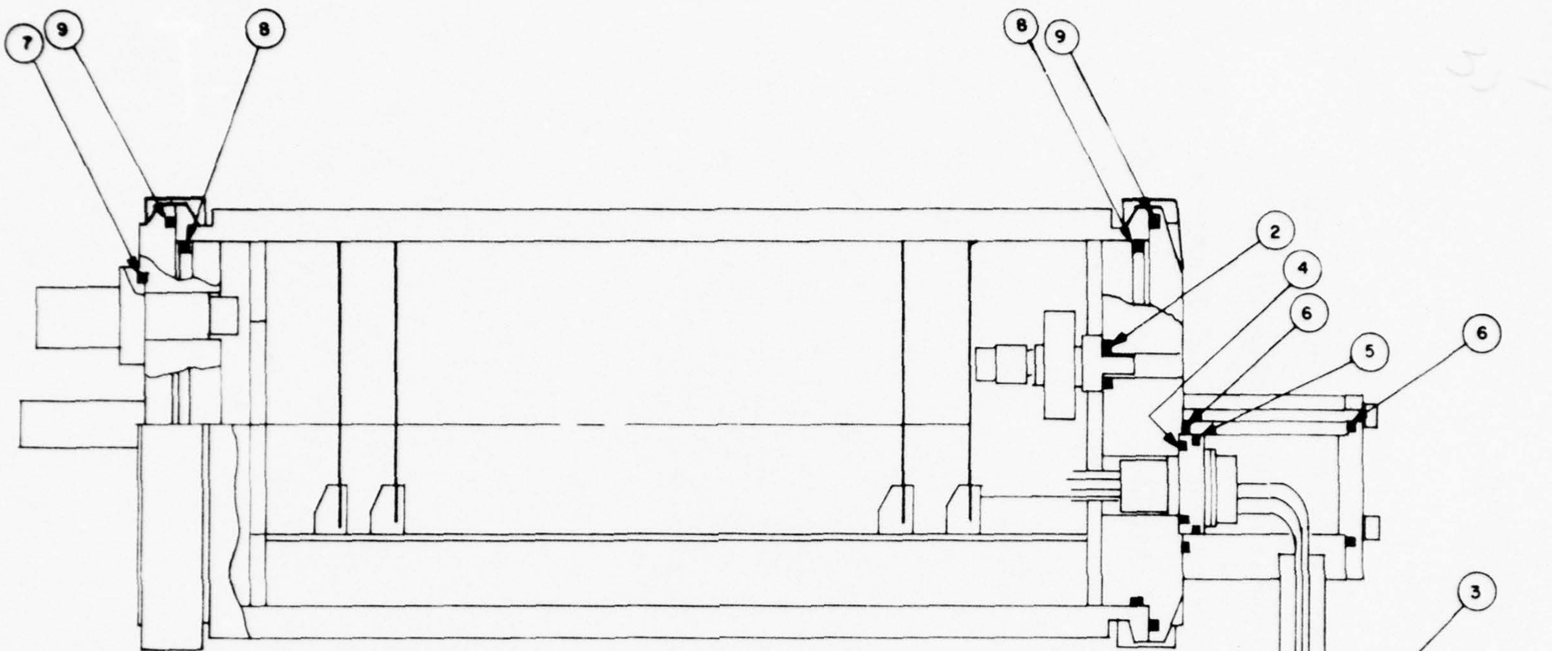
1) Remove Bendix connector between wiring harness and sensor head.
2) Remove three screws that hold the sensor head to the bottom end cap.
3) With bottom cap off remove transformer through the upper end of the sensor assembly with gentle pressure on transformer from below.

The Underwater Unit is reassembled in reverse sequence. Inspect, clean or replace and regrease 'O' rings; they should be lightly coated with Parker "Super 'O' Lube". Before installing bulkhead transformer, fill sensor head with Freon gas. Before installing top cap, purge pressure case by filling with Freon gas. Attach V-band clamps and torque to 60 inch-lbs.

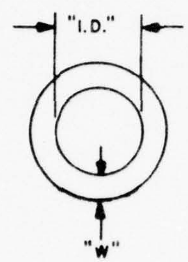
SERVICE ACCESS TO DECK UNIT

Deck Unit

To gain access to the circuit cards and 0.3 Amp down cable power fuse in the deck unit remove the six screws on top of the unit and lift off the top cover. A standard Cambion Model 714-1100-01 extender card may be used for troubleshooting and testing.



"O" RING SEALS FOR UNDERWATER UNIT				
ITEM NO.	FUNCTION	"O" RING NO. (PARKER)	"I.D." (IN INCH)	"W" (IN INCH)
1	CONDUCTIVITY CELL THERMISTOR PLATINUM THERM.	2-011	0.301	0.070
2	PRESSURE TRANSDUCER	2-013	0.426	0.070
3	SENSOR HOUSING TO MOUNTING PLATE	2-024	1.114	0.070
4	BULKHEAD SEAL TO BOT. CAP	2-028	1.364	0.070
5	BULKHEAD SEAL TO SENS. HSG.	2-030	1.614	0.070
6	SENS. HSG. TO BOTTOM CAP SENS. HSG. TO HOUSING CAP	2-032	1.864	0.070
7	TOP OUTPUT BULKHEAD CONN.	2-213	0.921	0.139
8	TOP END CAP & BOT. END CAP	2-256	5.734	0.139
9	TOP END CAP & BOT. END CAP	2-260	6.484	0.139



"O" RING SEALS FOR UNDERWATER UNIT

Fig. 2.2.4

TESTS & CALIBRATION

This section of the manual is to outline the tests and calibration procedures necessary for users to check the calibration of their instruments. In additon to a dc voltmeter, frequency counter and an oscilloscope, it is necessary in performing the following calibrations to have a platinum standard thermometer and Mueller bridge, a supply of standard sea water, (at least 3 ampoules), magnetic stirrer, a Dewar flask large enough to accomodate the sensor housing, a precision dead weight pressure tester, and a well stirred insulated constant temperature bath. Some independent method of measuring conductivity is also desirable such as a Model CT-2 Temperature-Conductivity Transfer Standard.

Precalibration Checkout Procedure

The following checkout must be performed before pre-cruise calibration.

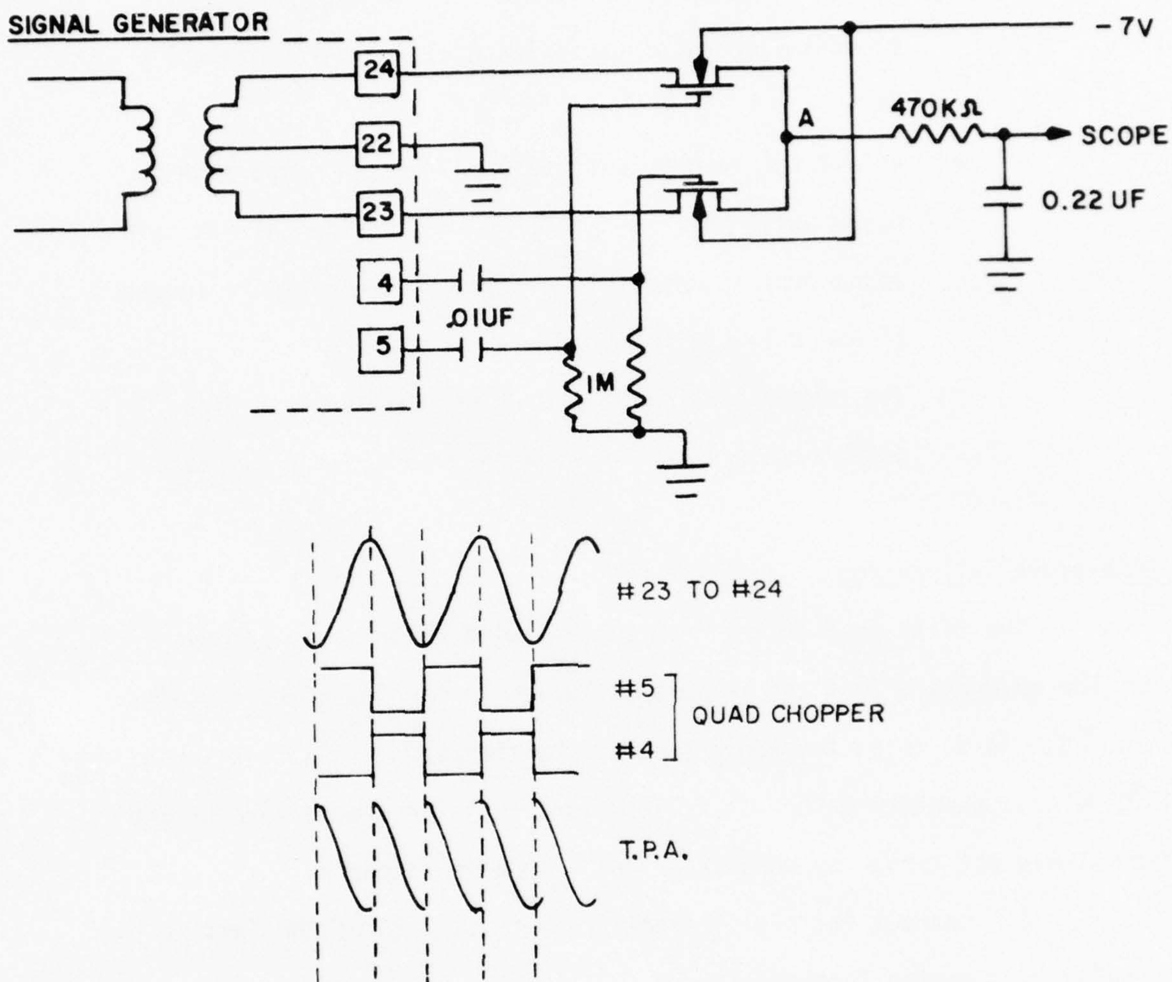
1. Remove the CTD Underwater Unit pressure housing.(2.2.2(3))
2. Measure the voltage levels on the power supply; J6, pins 30-35 should be 12V $\pm$10%. Adjust the 6V line, Pin 20-29, with the trim pot R6 on the power supply board to one half of the measured 12V value within $\pm$.01 Volts.
3. Check the frequency on pin 8 of the signal generator J13; it should measure 10,000 Hz $\pm$ 20 Hz.
4. Check that the sine and square wave 10 kilohertz references

sources are exactly in phase. The test circuit illustrated is required.(Figure 2.3(2))

5. With the signal generator still in the underwater unit connect the test fixture to connector J13 as shown. The dc output should be less than $\pm$5mV; if not, adjust the series-parallel tuned circuit on the signal generator board as follows:
   a) Remove jumper labeled J7 on schematic and component layout.(Figure 5.1.13; 5.1.13(1))
   b) Tune slug in transformer T1-J13 to give zero output $\pm$5mV at output point on test fixture.
   c) Replace jumper.
   d) Tune slug in L1 on J13 to give zero $\pm$5mV output on test fixture.
   e) Reseal tuning slugs in T1 and L1 with R.T.V.

   The signal generator board is now aligned.

6. Procedure for adjusting the zero and bias controls on the AC comparator, J7.
   a) Remove all four sensor interface boards,(J1-J4).
   b) Jumper pin 12 to #15 on the conductivity interface back plane connector J4.
   c) With an oscilloscope triggered from pin 31 on the memory and multiplexer board, observe pin 5 on the adaptive sampling board (time base 1ms/cm ,sensitivity 10 Volt/cm, dc coupled. The correct waveform is the


SIGNAL GENERATOR
24
22
23
4
5
.01UF
1M
-7V
A
470KΩ
SCOPE
0.22 UF
#23 TO #24
#5
#4
QUAD CHOPPER
T.P.A.

lower signal in figure 2.3(3).

d) Adjust the bias potentiometer, P1 on the comparator to minimize the sinusoidal signal in region marked "A".

e) Adjust the zero potentiometer P3 on the comparator board until the region 'A' becomes horizontal (as this adjustment is made this region will increase in length to about 1 ms).

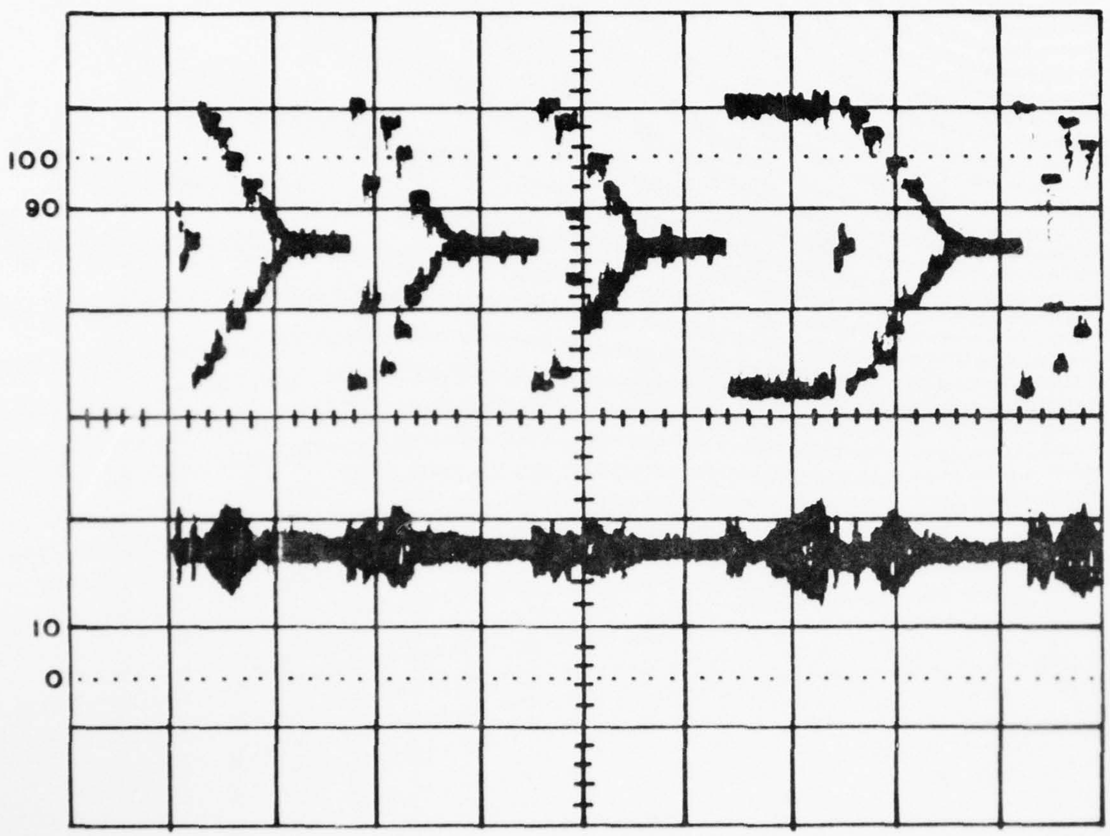
f) The comparator is now set up and the zero and bias potentiometers may be locked with R.T.V. or glyptal.

Temperature Calibration

The first step in the temperature calibration is to ensure that the quadrature from the sensors is nulled in the interface circuits at 15^{0} C. To do this, the sensors should be immersed in a well stirred $15^{0}C \pm 1^{0}C$ temperature bath. It is important that the temperature of the bath should not change by more than $.001^{0}C$ in a few seconds.

1. Connect the oscilloscope probe to pin 26 of the fast response interface board, J3. The 10 kilohertz sine wave at this point should be nulled using the quadrature adjustment potentiometer, P1, on the fast response board, J3.
2. Move the oscilloscope probe to test point 6 on the AC comparator board, J7 with the oscilloscope triggered from pin 31 on the memory and multiplexer board, J10. Set the time base of the oscilloscope to 5 milli-seconds per divi-

COMPARATOR TEST POINTS



Comparator Test Point 1
1 volt/div.

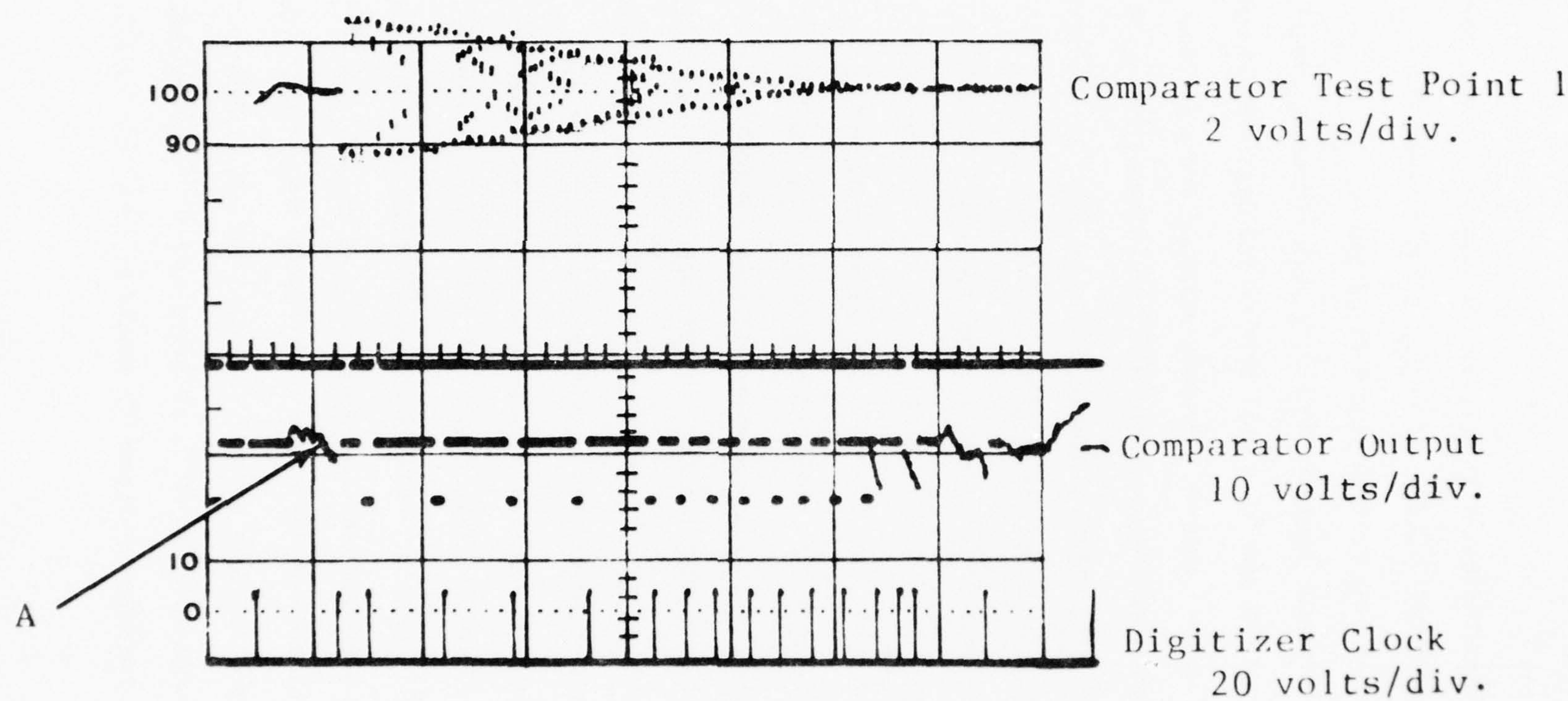
Comparator Test Point 6
200 mv/div.

Fig. 2.3(3)

sion, and the vertical sensitivity to .200 volts per division. The signal during the second 10 milliseconds of the trace should be nulled with the quadrature adjustment potentiometer, P1, on the temperature interface board, J4. The adjusting screw on the quadrature potentiometer on the fast response board (P1 on J3) should now be secured with R.T.V. or glyptal. (See figure 2.3 (4))

3. When the temperature bath is stable, note the temperature on the deck unit display. Adjust the quadrature potentiometer, P1, on the temperature interface board to give a two-thirds maximum output during the temperature period, observing the quadrature signal on the oscilloscope at TP6, J7 as before. The quadrature potentiometer, P2 on comparator J7 should now be adjusted to restore the temperature value displayed on the deck unit as noted when the temperature quadrature was nulled. The quadrature potentiometer, P1, on the Temperature interface board should now be turned back through zero until it is at two-thirds saturation on the other side of zero. The indicated temperature display should not have changed by more than a few millidegrees from the value at zero quadrature and two-thirds quadrature in the opposite direction. It may be necessary to trim the quadrature potentiometer, P2, on the comparator to obtain minimum variation in the displayed temperature when the temperature interface quadra-

COMPARATOR TEST POINTS



Oscilloscope triggered externally from pin 31 on Memory and Multiplexor jack, time base 1 ms/div.

Fig. 2.3(4)

ture potentiometer is adjusted ± 2/3 saturation; max. permissible error ±0.002°C. Readjust potentiometer P1,J7 by criteria of step 2, then secure P1,J2 and P2, J7.

4. Cover the sensor assembly with fine mesh screen to protect the sensor and develop a well stirred ice bath with shaved ice and water. Immerse the probe assembly and a platinum resistance thermometer connected with a Mueller bridge in the bath. The entire assembly should be left to stabilize for at least one half hour before continuing the test. When the ice bath has stabilized as confirmed by several consecutive identical readings of the Mueller bridge, adjust the zero pot, P2, on the temperature interface board, J7, until the temperature indicated by the CTD agrees with the Mueller standard to within ±.001°C.

5. Remove the sensors from the ice bath and immerse them in a well-stirred bath of water at about 30°C. When the bath has been allowed time to stabilize, the Mueller bridge should be read several times and the sensitivity potentiometer, P3, on the temperature interface board should be adjusted to make the reading on the CTD deck unit agree with the platinum standard temperature to within ±.001°C. To check the linearity of the temperature circuitry it is necessary to measure several points in the well-stirred bath between zero and 30°C, at least each 5° is recommended. The maximum non-linearity should be less than .002°C.

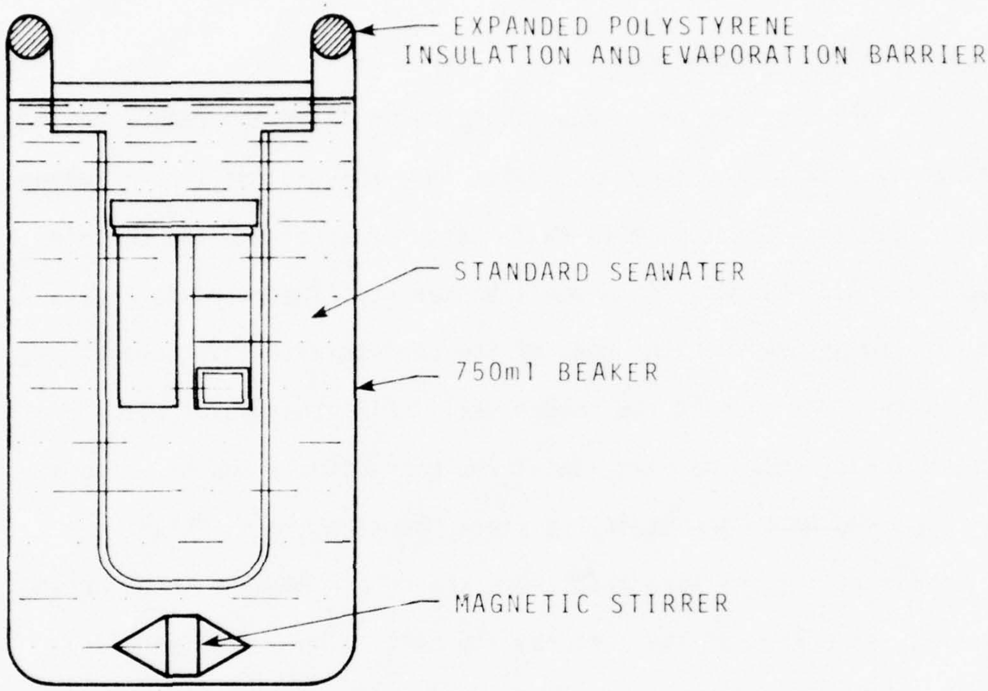
After the calibration is completed, check that all the potentiometers which have been adjusted are secured with R.T.V. or glyptal.

Field Conductivity Calibration

Before starting the conductivity calibration the cell should be cleaned by soaking for several minutes in a solution of 1 part saline dissolvent (General Chemical MT6) to 25 parts of water. After cleaning immerse the sensor assembly in a small beaker as illustrated in Figure 2.3(6) taking care to ensure that the ends of the conductivity cell tube do not come within 3/4 inch of the beaker wall. Fill the beaker with standard sea water of known salinity until the conductivity sensor is completely immersed up to the stainless steel mounting block. Start the magnetic stirrer, making sure that there are no air bubbles in or around the tube at the bottom of the conductivity cell. The beaker should be as well sealed as possible to minimize evaporation and the standard sea water should be warmed before opening and allowed to cool slowly during the conductivity calibration so that air is going into solution rather than coming out and forming bubbles which cause problems during the calibration. The first filling of standard sea water will almost certainly be wasted by the time the air bubbles have been removed and the bath is stable since evaporation will probably have been sufficient to cause a significant change in the salinity resulting in a faulty calibration.

Observing test point 6 on the comparator board, J7 and triggering the scope from pin 31 of the memory and multiplexer board, J10,

Fig. 2.3(6)



EXPANDED POLYSTYRENE
INSULATION AND EVAPORATION BARRIER
STANDARD SEAWATER
750ml BEAKER
MAGNETIC STIRRER

the quadrature signal during the 3rd 10ms period of the trace should be nulled by means of the quadrature potentiometer, P1, on the conductivity interface board, J4. (See Figure 2.3(4))

Without disturbing the arrangement illustrated in the figure, stop the magnetic stirrer, remove the standard sea water from the beaker by means of a small siphon tube, and refill the beaker with fresh warm standard sea water. Several readings of conductivity and temperature should be noted and the salinity computed with the equation given in Appendix 7.4. The conductivity sensitivity adjustment P2 on J4 should be trimmed until the indicated conductivity agrees with the expected conductivity for standard sea water at the measured temperature. After this value has been correctly set, the measurement should be repeated with at least one more filling of standard sea water to confirm that the adjustments are correct. This conductivity calibration is a single point calibration: it is intended as a performance check when sophisticated calibration equipment is not available. It should be emphasized that a temperature error of .001^{o}C will introduce a conductivity error of about .001 mmho/cm.; it is important to note temperature values closely during the conductivity calibrations.

Note: Salinity = 1.80655 x Chlorinity quoted on Std. Sea Water Ampoule

Laboratory Conductivity Calibration

Clean the cell and adjust the quadrature of the Conductivity Interface according to the steps outlined in the Field Conductivity Calibration procedure .

Zero offset adjustment procedure:

1. Set zero potentiometer, P3, J4, to mid-range by observing wiper with an oscilloscope and adjusting for null output with respect to ground.
2. Measure two known conductivities at extremes of the range (i.e. 10 mmho, G_L, and 60 mmhos, G_H, and correct measured conductivity for thermal effects on the cell using:

$$G_{Corrected} = G_{Indicated}\ (1 - \alpha\ (T - 15^{o}C)\ )$$

where $\alpha = 6.5 \times 10^{-6}\ {}^{o}C^{-1}$ = coeff. of expansion of alumina ceramic

ΔG_L is the error at Cond., G_L

ΔG_H is the error at Cond., G_H

Find ΔG_H, and ΔG_L where ΔG= Actual Cond. - $G_{Corrected}$

Linearly extrapolate these two values to zero and find intercept. (error at conductivity zero)

$$\text{Zero offset, } A = \Delta G_H - G_H\ \left(\frac{\Delta G_H - \Delta G_L}{G_H - G_L}\right)$$

For example:

ΔG_H = .012 mmho ΔG_L = .004 mmho.

if G_H = 60 mmho and G_L = 10 mmho.

$$A = .012 - \frac{.008\ (60)}{50} = .0024.$$

3. Using high known conductivity adjust zero potentiometer, P3, J4, to make intercept zero (i.e. decrease reading by A)

Sensitivity adjustment using high known conductivity:

Adjust sensitivity potentiometer, P2, J4, to make full scale reading correct - making allowance for temperature dependance of cell using:

$$G_{Ind} \ (1 - \alpha \ (T - 15) \ ) = G_{known}.$$

Pressure Calibration

The following adjustments should be made in the sequence indicated. As in the previous sections, it will first be necessary to null the quadrature signal from the sensors. Test point 6 on the comparator board, J7, should be observed using an oscilloscope triggered from pin 31 on J10 on the memory and multiplexer board. The quadrature signal in the pressure region, the first 10 milliseconds after the trigger, should be nulled by the same procedure for temperature and pressure, by means of the zero quadrature nulling potentiometer, P3, on the pressure interface board, J1. With the pressure transducer at ambient pressure, the zero adjust potentiometer,P2,should be adjusted to cause a zero reading on the deck unit. The dead weight tester should be set to full scale, first the sensitivity quadrature potentiometer, P5, should be adjusted, and then the sensitivity potentiometer, P4, should be adjusted to cause the deck unit to display the correct full scale reading.

Several intermediate points should be checked to establish the linearity of the pressure transducer.

To perform the temperature coefficient adjustments, it is necessary to remove the pressure transducer from the end cap and to mount it in a special block as Figure 2.13(10)

CAUTION: PRESSURE TRANSDUCER TORQUE MUST NOT EXCEED 60 INCH-POUNDS.

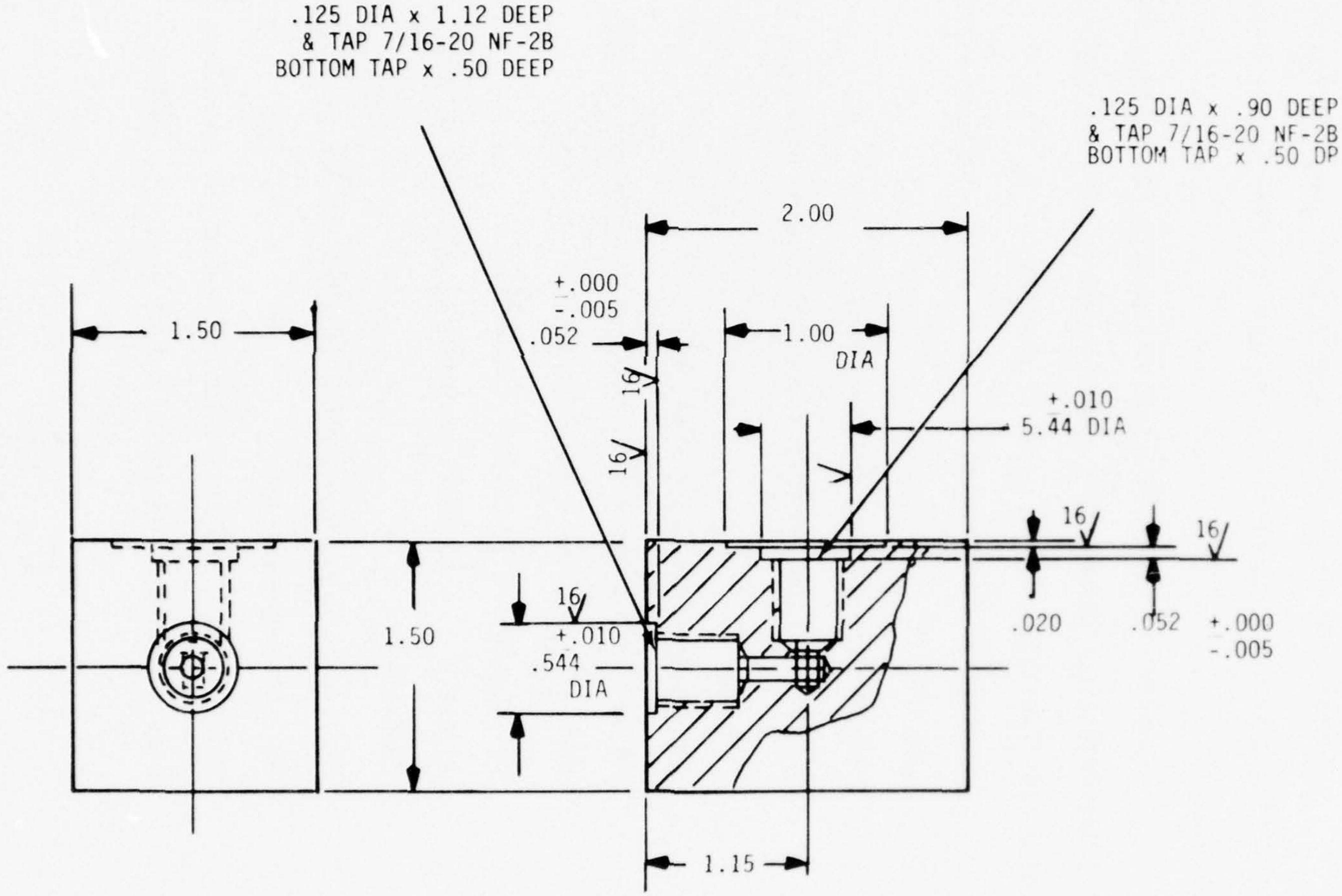
Pack this block and transducer in ice and allow the temperature to stabilize. After approximately one half hour, adjust the zero temperature coefficient potentiometer, P1 on J1, to bring the pressure reading back to zero with zero pressure applied. The pressure transducer should now be exercised to full scale using a dead weight tester as before and the jumper links in the scale temperature coefficient adjustment should be shifted to regain the room temperature full scale readings on the deck unit. One link shift is equivalent to either .02% or .04% change depending on the position of link J_S on board J1.

CAUTION: PRESSURE TRANSDUCER TORQUE MUST NOT EXCEED 60 INCH-POUNDS.

Replace the transducer in the end cap, and readjust zero and zero quadrature; secure potentiometer adjusting screws.

PRESSURE TRANSDUCER

TEMPERATURE COEFFICIENT TEST FIXTURE



UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES

Fig. 2.3(10)

OXYGEN CALIBRATION PROCEDURE

Install 'O' rings in O_2 receptacle housing. Screw cap on the O_2 receptacle housing and install screw and 'O' ring in the side of the housing.

Immerse the sensor housing in ice bath for several hours until the resistance between the green and white wires at the receptacle housing has stabilized. Note value of resistance (R_t 0°C).

Connect GR box to pins 28 and 29 of O_2 backplane connector, J5.

Set GR box to R_t0°C measured above

Adjust T_o potentiometer for +00.0 reading on oxygen temperature display

Set GR Box to R_t 25°C = 41.2kΩ.

Adjust T_s pot for +25.0 on oxygen temperature display

Recheck R_t0°C and R_t25°C points.

Set V_{os} pot fully counter-clockwise

Adjust V_{os} cw to just get 0.000 on D/U with no load resistor connected.

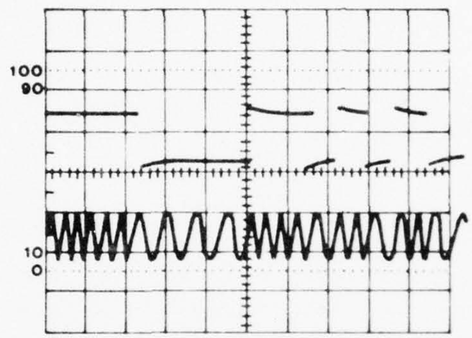
Measure voltage, E, at pin 2 of AD580 to pin 29 of connector, J5. Note value as E

Using 800kΩ 0.1% load resistor between red and black wires on sensor housing. Adjust O_2 pot to read I_{cal} on D/U.

$$I_{cal} = \frac{E}{800k\Omega}$$

TEST POINT WAVEFORMS AND SEQUENTIAL TIMING DIAGRAM

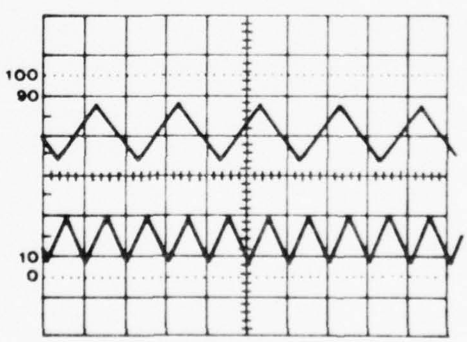
TTY/FSK WAVEFORMS



Data Pin #13, IC/4
10 volts/div.

FSK output (Pin #6 jack.)
2 volts/div.

Time base uncalibrated >200 ms/div.

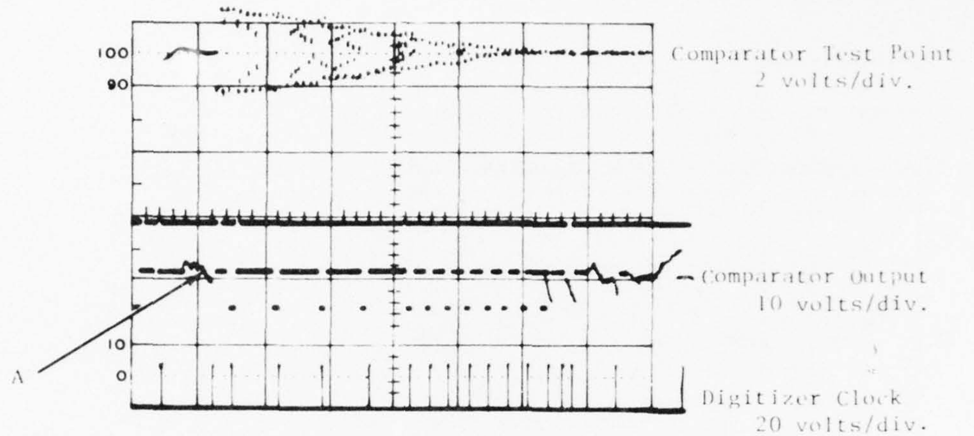


Pin #1, IC/4
200 mv/div.

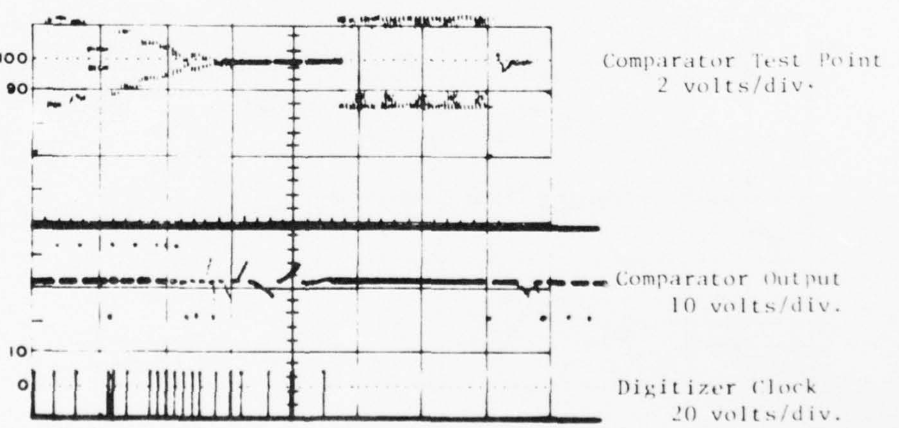
Pin #10, IC/4
200 mv/div.

Time base 100 μs/div.

COMPARATOR TEST POINTS

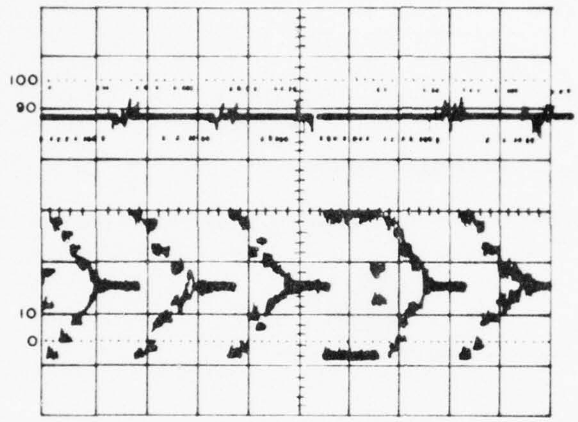


Oscilloscope triggered externally from pin 31 on Memory and Multiplexor jack, time base 1 ms/div.



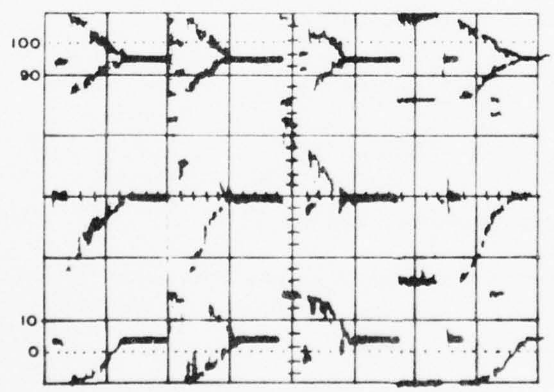
Oscilloscope triggered externally from pin 31 on Adaptive Sampling jack, time base 2 mS/div.

COMPARATOR TEST POINTS



Comparator Output
10 volts/div.

Comparator Test Point 1
1 volt/div.



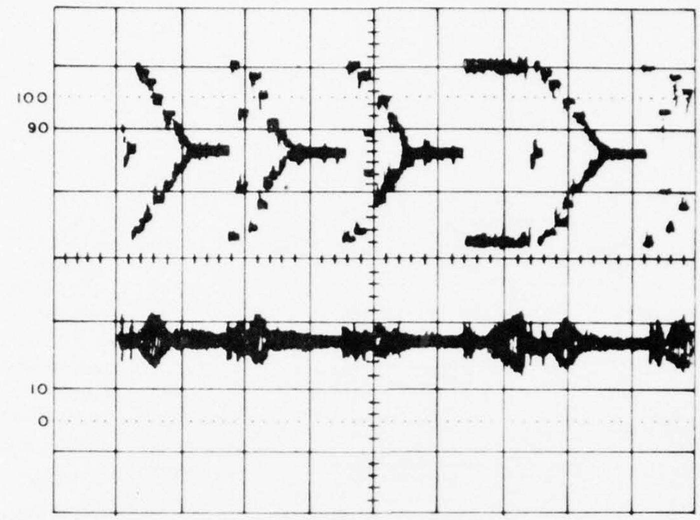
Comparator Test Point 1
2 volts/div.

Comparator Test Point 2
1 volt/div.

Comparator Test Point 3
5 volts/div.

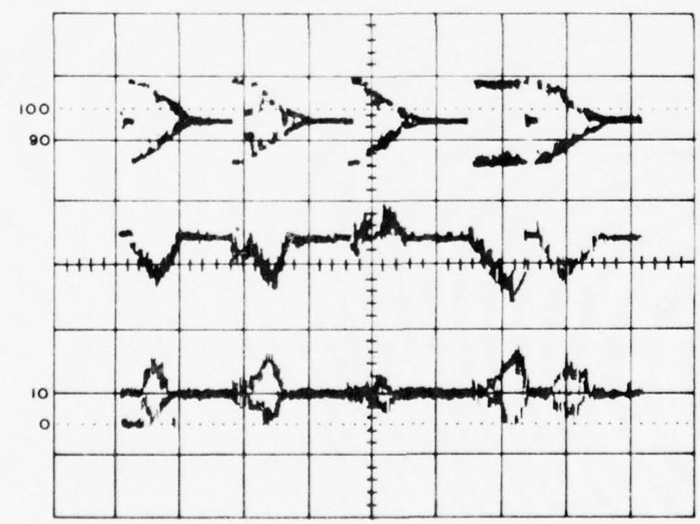
Oscilloscope externally triggered from pin 31 on the Memory and Multiplexor jack, time base 5mS/div.

COMPARATOR TEST POINTS



Comparator Test Point 1
1 volt/div.

Comparator Test Point 6
200 mv/div.



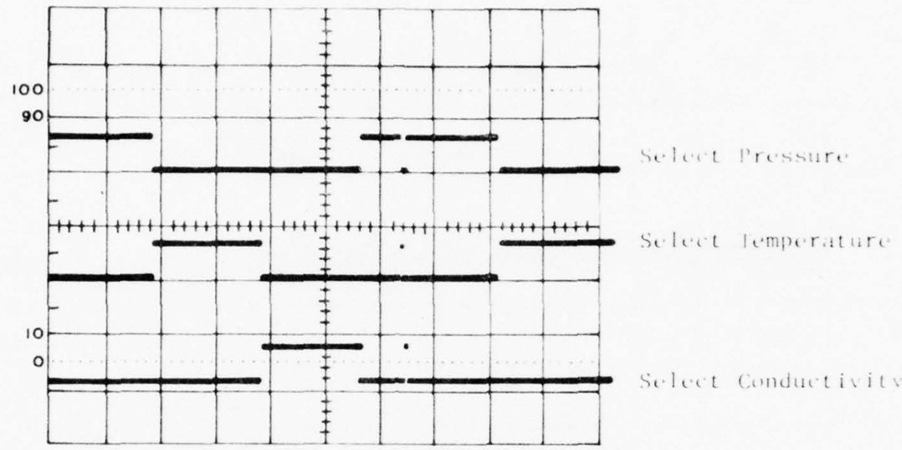
Comparator Test Point 4
2 volts/div.

Comparator Test Point 5
1 volt/div.

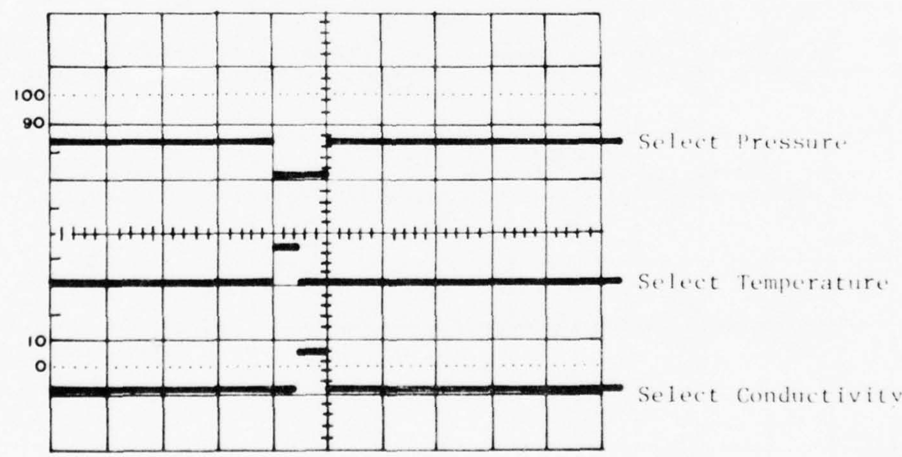
Comparator Test Point 6
200 mv/div.

Oscilloscope externally triggered from pin 31 on the memory and multiplexor jack, time base 5 ms/div.

MEMORY AND MULTIPLEXOR

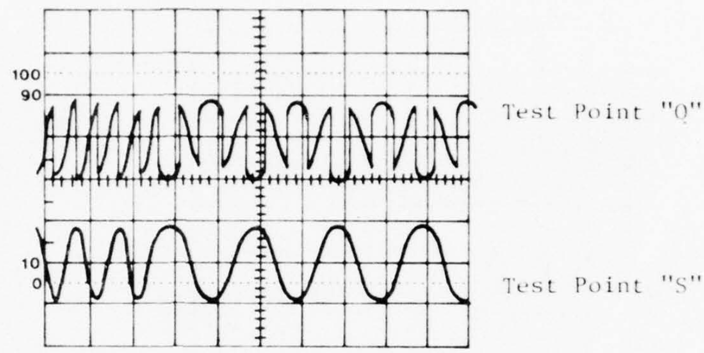


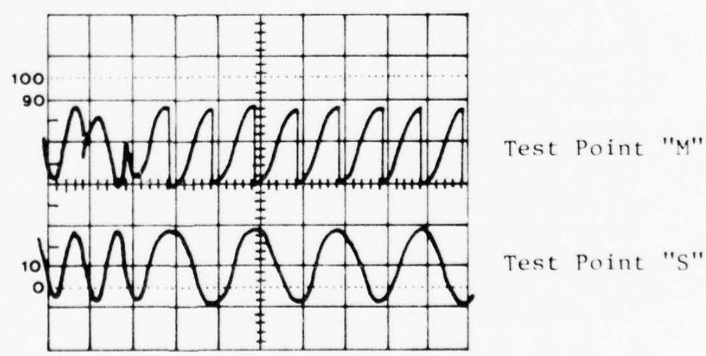
Oscilloscope externally triggered from pin 31 on Memory and Multiplexor jack all traces 20 volts/div., time base 5 mS/div.



Expansion of "read cycle" approximately 32 mS after start of above trace, time base 200 µs/div., sens 20 volts/div.

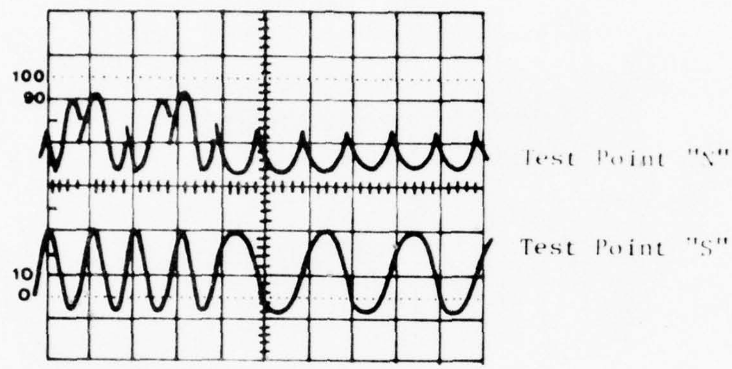
DEMODULATOR TEST POINTS

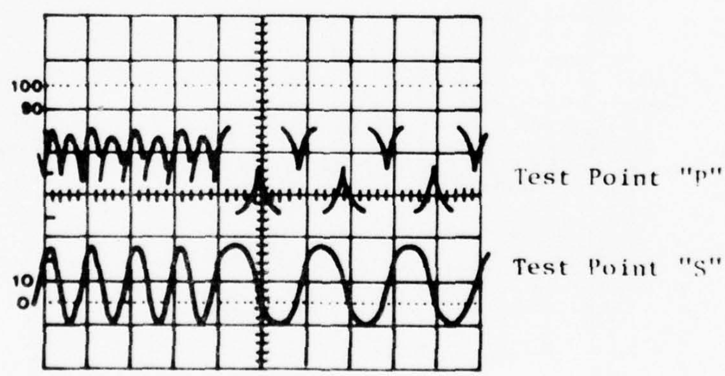




Oscilloscope sensitivity 2 volts/div.,
time base 100 μs/div.

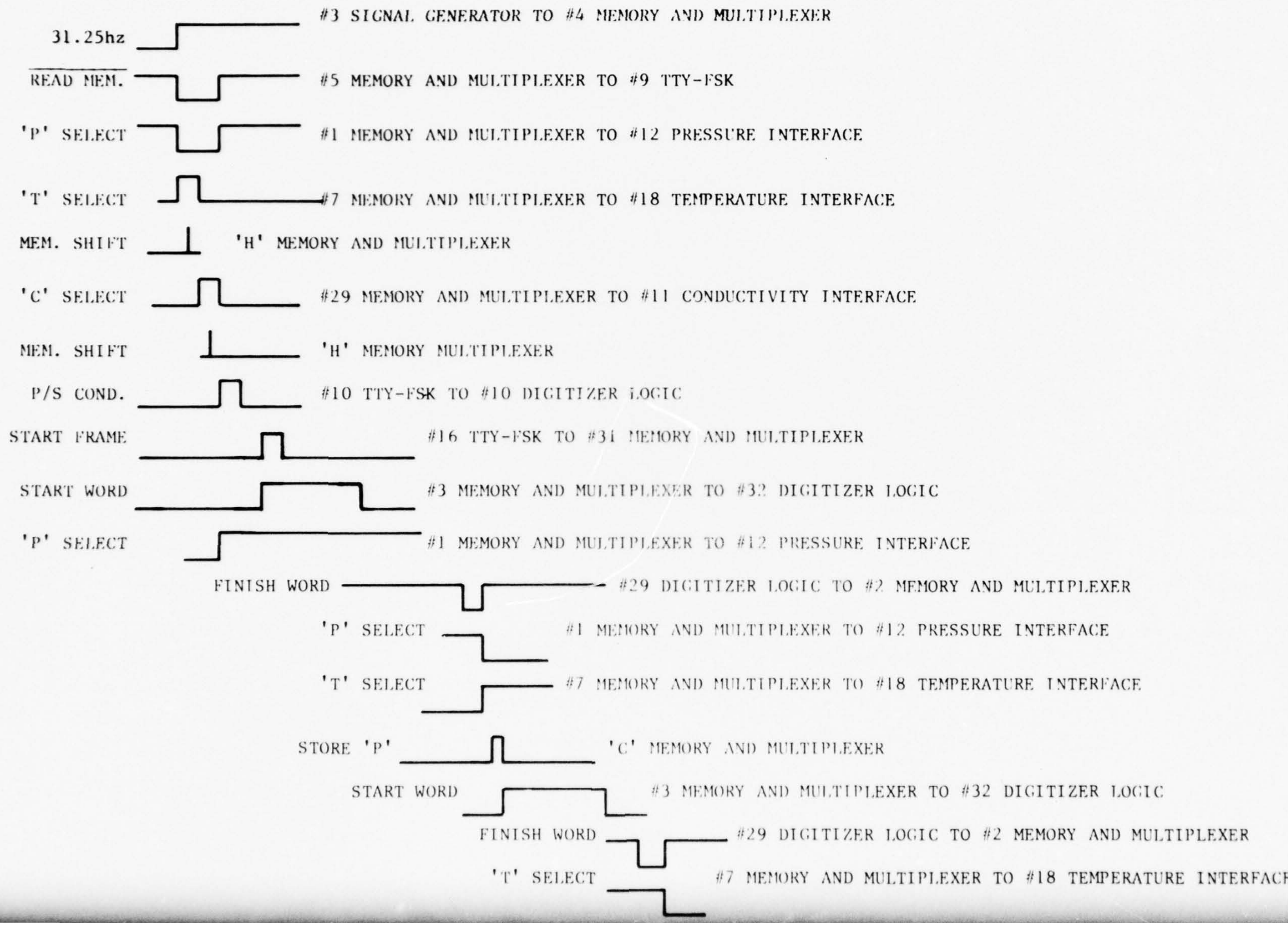
DEMODULATOR TEST POINTS





Oscilloscope sensitivity 2 volts/div.,
time base 100 μs/div.

MARK IIIB CTD UNDERWATER UNIT TIMING SEQUENCE CHART




START FRAME
#16 TTY-FSK TO #31 MEMORY AND MULTIPLEXER
START WORD
#3 MEMORY AND MULTIPLEXER TO #32 DIGITIZER LOGIC
'P' SELECT
#1 MEMORY AND MULTIPLEXER TO #12 PRESSURE INTERFACE
FINISH WORD
#29 DIGITIZER LOGIC TO #2 MEMORY AND MULTIPLEXER
'P' SELECT
#1 MEMORY AND MULTIPLEXER TO #12 PRESSURE INTERFACE
'T' SELECT
#7 MEMORY AND MULTIPLEXER TO #18 TEMPERATURE INTERFACE
STORE 'P'
'C' MEMORY AND MULTIPLEXER
START WORD
#3 MEMORY AND MULTIPLEXER TO #32 DIGITIZER LOGIC
FINISH WORD
#29 DIGITIZER LOGIC TO #2 MEMORY AND MULTIPLEXER
'T' SELECT
#7 MEMORY AND MULTIPLEXER TO #18 TEMPERATURE INTERFACE
'C' SELECT
#29 MEMORY & MULTIPLEXER TO #11 CONDUCTIVITY
STORE 'T'
'C' MEMORY MULTIPLEXER
START WORD
#3 M. and M. to #32 DIGITIZER LOGIC
FINISH WORD
#29 DIG. LOGIC TO #2 M. AND M.
RESET COUNTER
'E' MEMORY MULTIPLEXER
'C' SELECT
#29 M. AND M. TO #11 CONDUCTIVITY
'P' SELECT
#1 M. AND M. TO #12 PRESSURE
31.25hz
#3 SIGNAL GENERATOR TO #4 MEMORY AND MULTIPLEXER
READ MEM.
#5 MEMORY AND MULTIPLEXER TO #9 TTY-FSK
PARALLEL SHIFT 'C'
#10 TTY-FSK TO #10 DIGITIZER LOGIC
START FRAME
#16 TTY-FSK TO #31 MEMORY AND MULTIPLEXER

Fig. 2.4(9)

2

CIRCUIT DESCRIPTIONS

PRESSURE INTERFACE

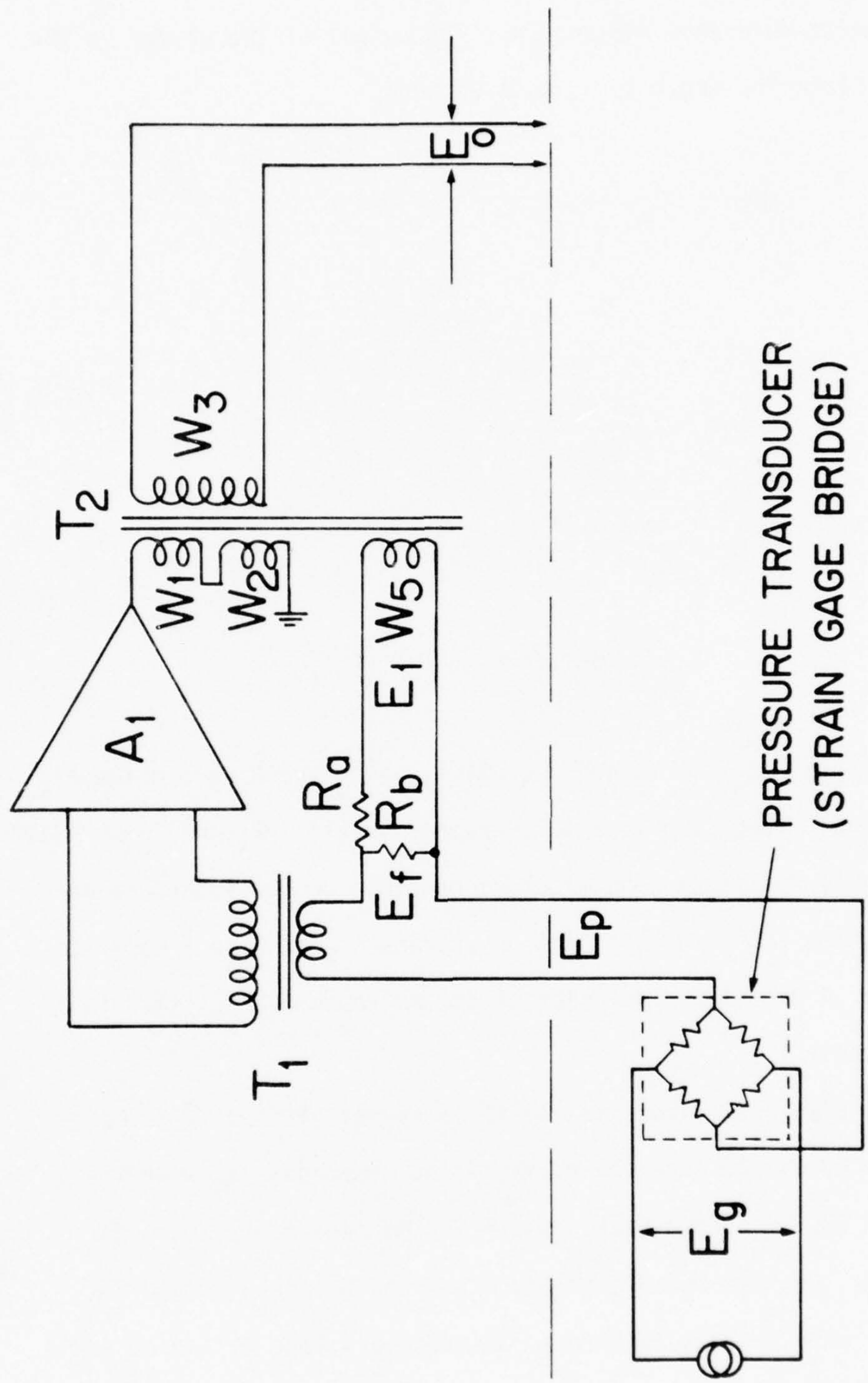
Pressure Interface: The pressure transducer is a 350 ohm bonded wire strain gauge bridge (Standard Control Inc. Model #211-35-440). Field and laboratory experience with this transducer has shown overall accuracy consistently better than $\pm$ 0.1% of full scale (Typical full scale is 6500 decibars).

Pressure Transducer Interface Circuit: The purpose of the interface circuit is to match the characteristics of the sensor to the requirements of the digitizer. The pressure transducer output is 2.5 millivolts full scale per volt of excitation, and the transducer is rated at 10 volts. To conserve power, the 10 kilohertz excitation is limited to 2 volts R.M.S. for an output range of 0 to 5 millivolts.

The digitizer measures the ratio of the sensor interface output voltage to the reference voltage, and full scale output (all "ones") from the digitizer occurs when the sensor interface output (digitizer input) is 500 millivolts. Consequently, the transducer output of 5 millivolts must be amplified by 100.

For overall accuracy and stability, it is critical that the gain and phase characteristics of the the ac amplifier be extremely stable. Referring to the simplified schematic, Figure 3.1.1 assume the open loop gain (A_0) of the feed-back amplifier consisting of T_1, A_1 and T_2 is infinite, and the feed-back from winding W_5 is negative; it can be shown by operational amplifier theory that the input to T_1 is zero. The pressure transducer is shown as the Wheatstone bridge excited by

Fig. 3.1.1



E_o
W_3
T_2
W_1
W_2
W_5
A_1
E_1
R_a
R_b
E_f
E_p
T_1
PRESSURE TRANSDUCER
(STRAIN GAGE BRIDGE)
E_g

the 10 kilohertz reference voltage Eg. The output of the bridge is the signal Ep. Since the input to T_1 must be zero,

$$\text{then} \quad E_p = -E_f$$

$$= E_1 \frac{R_b}{R_a + R_b}$$

$$E_1 = E_0 \frac{W_5}{W_3}$$

$$\text{so} \quad \frac{E_0}{E_p} = \frac{W_3}{W_5} \frac{R_a + R_b}{R_b}$$

$$= \text{closed loop gain.}$$

Since the ratio of $\frac{W_3}{W_5}$ on T_2 and the values of R_a and R_b are extremely stable the closed loop gain is also extremely stable. R_a and R_b are S102 Precision Vishay resistors mounted close together on the interface card, and W_3 and W_5 are the fixed windings on a transformer, also a very stable quantity. A detailed discussion of the ac feedback amplifier is given in Appendix 7.1.

The stable 10 kilohertz amplifier represented as A_1 is made up of Q1, Q2, Q3 and Q5 with their associated components between transformer T1 and T2. The feed-back network is composed of the resistor network P4, R7, R8, R20 and a quadrature nulling network, P5 and C4. Both in-phase and quadrature zero adjustments are made by adding small fractions of the bridge excitation signal E_g into the input of A_1

through networks P2, R6, R21, R22 and P3, C3 respectively to cancel fixed offsets.

To compensate for possible nonlinearity in the pressure transducer, winding W4 and resistors R4 and R5 are provided. By means of the link J1 it is possible to connect the linearize feed-back winding in such a manner as to increase or decrease the output corresponding to the maximum pressure. In normal use R5 is left open-circuit and R4 is a short-circuit. Unfortunately, the strain gauge pressure transducer is sensitive to large changes in temperature which the instrument will experience as it is lowered through the ocean from the surface to the cold deep water at the bottom. To compensate for this apparent pressure reading caused by temperature, a temperature compensation circuit is provided. The temperature of the pressure transducer is monitored by a thermistor connected across pins 25 and 26 of the interface card. The thermistor is the variable in a bridge which includes the primary of transformer, T3, and resistor, R1. This network is excited by the reference voltage Eg or half of the reference voltage, Eg/2, depending upon the position of jumper, JS. The voltage appearing across the primary of T3, therefore, is a function of the out-of-balance or difference in resistance of the thermistor and resistor R1.

Temperature compensation is made as an offset correction at zero pressure, and a sensitivity correction at full scale pressure. The offset is adjusted at $0^{o}C$ and zero pressure with "TC" potentiometer, P1; the sensitivity is corrected automatically by slightly increasing or decreasing the transducer excitation as a function of temperature. The

sense and magnitude of the correction is determined by jumpers JR and JT on T3. Adjustment of the temperature compensation is described in the test and calibration section, 2.3; these tests require a pressure standard and an ice bath.

The bipolar outputs of the pressure interface appear on windings 6 and 3 on transformer T2. By means of Q4 and Q6 in conjunction with IC1 and resistors R18, R19 and diodes CR1, CR4, CR5 and CR6 the appropriate output is selected and connected to the digitizer at the appropriate time during the digitization cycle. The output transformer T2 has a center tapped winding W3 - W6. The center tap is connected to the analog common and output signals $+E_s$ and $-E_s$ are connected to switches Q4 and Q6 respectively. IC1 examines the pressure select and sign lines and presents the appropriate signals to the digitizer under the control of the digitizer logic and memory and multiplexer circuits.

TEMPERATURE INTERFACE

Sensor: The temperature sensor is dual 100 ohm element platinum resistance thermometer manufactured by Rosemount Engineering Co., their model 171-BJ.

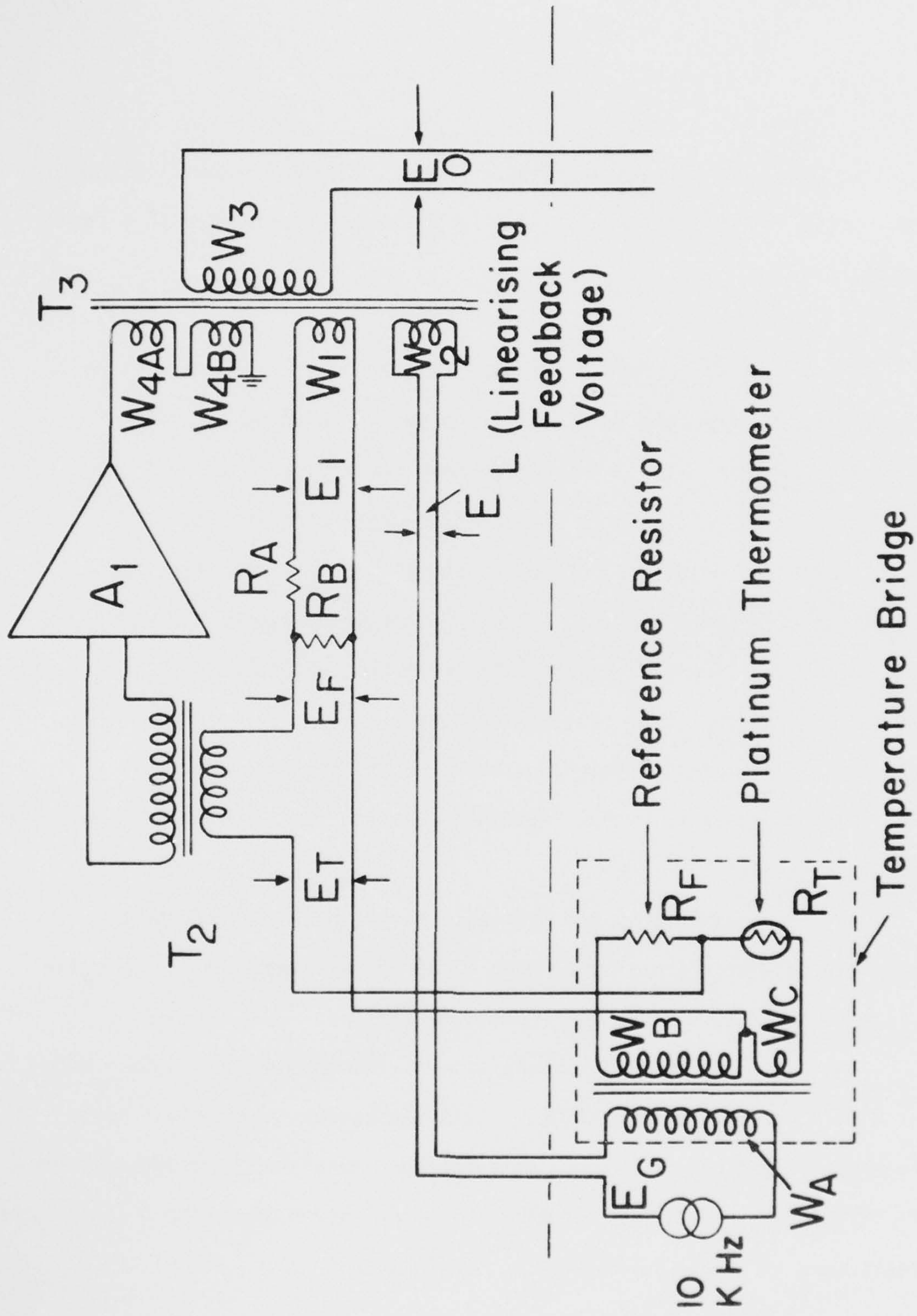
Temperature Interface: The platinum therometer interface circuit is essentially the same as for pressure and is shown in simplified schematic, Figure 3.1.2. The differences are the form of the sensor bridge and the addition of a "linearizing" feed-back signal.

The sensor bridge is made up of the platinum thermometer, R_T, a precision reference resistor, R_F and the two windings, W_B and W_C of the bridge transformer. The transformer bridge offers several advantages over a conventional four resistor bridge.

1) It provides efficient matching to the signal source.
2) It has lower output impedance, leading to a lower signal to noise ratio.
3) It requires only one precision resistor instead of three.
4) The ratio transformer arms W_B and W_C have essentially no ratio error or drift with temperature or time.

The platinum therometer resistance is 200 ohms at 20° (185.3 ohms at 0°C), and self-heating effects limit the maximum permissible current to 1mA. In the platinum thermometer bridge, sensitivity is greatest when R_F is infinite; since the actual value of R_F is ten times the 0°C resistance of the thermometer, the sensitivity is about 90% of the

Fig. 3.1.2



T_3
W_3
E_O
W_{4A}
W_{4B}
W_1
W_2
E_L (Linearising Feedback Voltage)
E_1
A_1
R_A
R_B
E_F
E_T
T_2
Reference Resistor
Platinum Thermometer
Temperature Bridge
R_F
R_T
W_B
W_C
E_G
W_A
10 KHz

theoretical maximum.

The resistance-temperature charactersitic of platinum resistance thermometers is not perfectly linear, and since R_F is a finite value, the current through R_F and R_T decreases with increasing temperature and results in increasing values of R_T, reducing the incremental sensitivity. The temperature interface adds a linearizing voltage, E_L, to the 10 kHz reference voltage, E_G,.

The addition of E_L to the generator voltage E_G increases the excitation voltage to the bridge as the temperature increases, negating the decrease in incremental sensitivity.

Combination of the platinum thermometer and interface circuit above result in a 10 kHz output of 0 to 500 millivolts between 0°C and 32.767°C to ± 0.0015°C with long term stability within 0.005°C per year. The response time of the thermometer is typically 250 milliseconds while the response time of the conductivity cell when moving through the water at 1 meter per second is typically 25 milliseconds. Salinity computed from the output of these two sensors alone results in "salinity spikes" when a sharp temperature gradient is encountered. These "spikes" can be reduced by computing a temperature lag correction from a running average of the two sensor readings, resulting in "smoothed" salinity data.

To more nearly match the thermal characteristics of the temperature and conductivity sensors, a technique is used to combine the high frequency response of a thermistor with the low frequency response of the platinum probe. These fast response thermistor circuits are described in Section 3.1.3.

Circuit: Amplifier A_1 is the discrete component amplifier with input

transformer T2 and output transformer T3. (A theoretical discussion of this amplifier is found in appendix 7.1). Feedback resistors R_A and R_B are formed by the resistive network R12, R13, R14 and P3. Resistors R1, R2, R3 and P2 permit zero adjustment, and the quadrature is nulled using P1 and C1.

The platinum thermometer, transformer, T1, and reference resistor, RF, are mounted in the sensor head. Turns ratio WB/WC and the resistive ratio $R_F:(R_{t1}+R_{t2})$ at 0^oC is designed so that the bridge output will be zero at 0°C. To linearize the bridge output, the "linearize" winding W2 is connected to increase the drive to the sensor bridge with increasing temperature. The modulated 10 kHz signal is output to the digitizer by switch Q4 or Q6 as controlled by gate IC1. The center tap of the output transformer is connected to signal common.

FAST RESPONSE TEMPERATURE INTERFACE

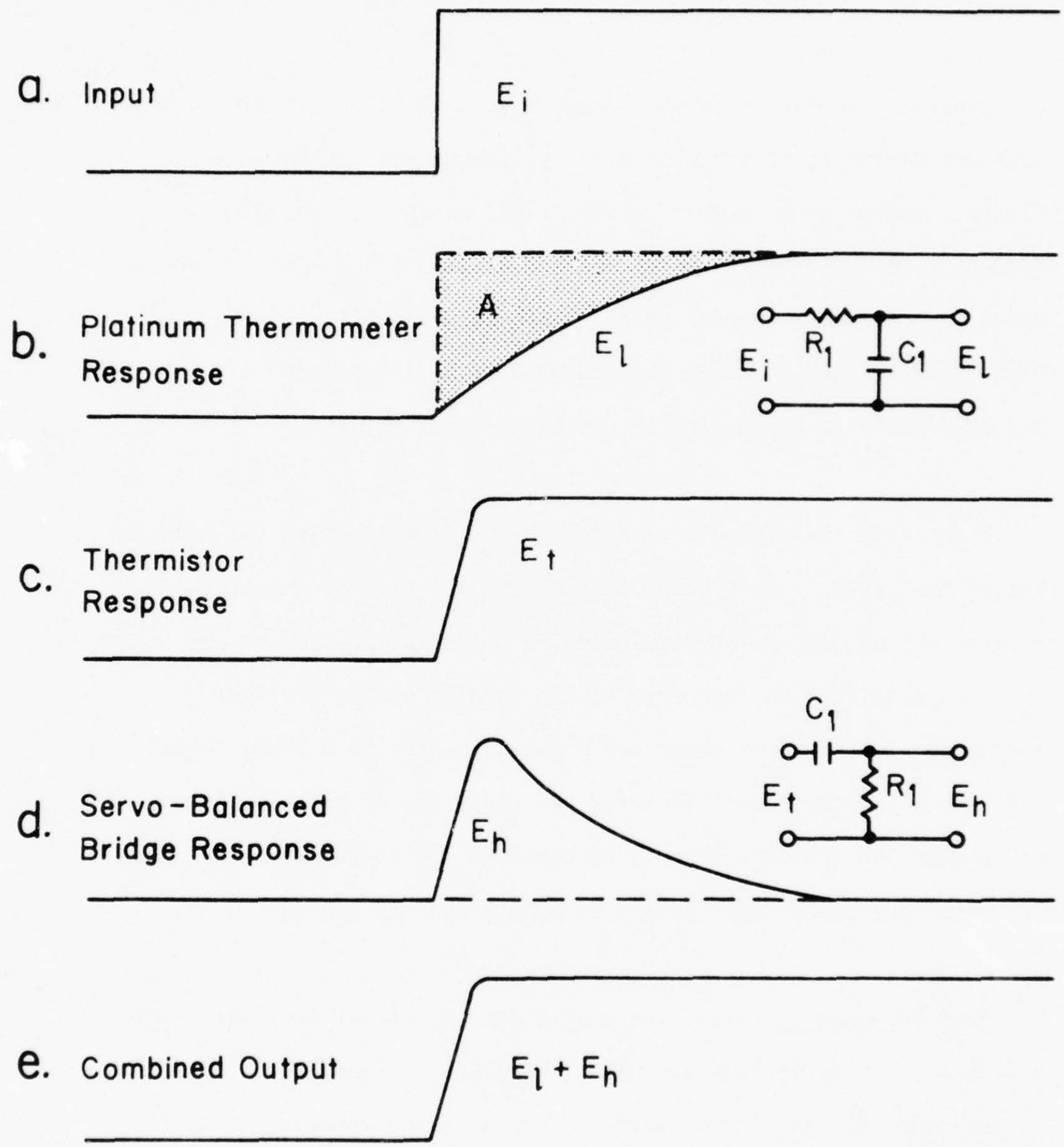
Sensor: The fast response temperature measurement is done with a miniature thermistor probe, with a 25 ms time constant, Fenwal No. GC32SM2 mounted on a ceramic paddle. This sensor is used with an electronic servo balanced bridge excited at 10kHz; the output from the bridge is precisely zero for steady state conditions. However, whenever temperature changes rapidly, the presence of an integrator in the control loop results in an exponentially decaying "error" signal.

With proper adjustment of an integrator time constant the response time of the servo is made equal to the response time of the platinum thermometer, and the bridge amplitude response is adjusted so the "error" signal is equal to the lag error in the reading of the platinum thermometer. The sum of these two signals results in a 10kHz output signal with the excellent linearity and stability of the platinum thermometer and the fast thermal response of the thermistor. An electrical analogy of this scheme is illustrated in Fig. 3.1.3.

Fast Response Circuit: The equivalent circuit of the fast response interface is shown in Fig. 3.1.3(2). Windings W_2 and W_3 of transformer T_1, resistor R_F and thermistor R_T form a bridge circuit which is excited by a 10 kHz signal Eg across winding W_1 of transformer T_1.

.. Under steady state conditions $E_1 = E_t - E_m = 0$ volts.

A step change in temperature causes a step change in the resistance


a. Input
E_i
b. Platinum Thermometer Response
A
E_l
E_i
R_1
C_1
E_l
c. Thermistor Response
E_t
d. Servo-Balanced Bridge Response
E_h
C_1
E_t
R_1
E_h
e. Combined Output
$E_l + E_h$

of R_T which causes E_1 to become non-zero. E_1 amplified by A_1 produces E_0 which is synchronously detected by M_2. The resultant dc output from M_2, E_d, is applied to an integrator A_2 and the output E_c drives one input of multiplier M_1; the other input of M_1 is Eg from winding W_4 of transformer, T_1. The 10 kH_z output of M_1, E_m, will change so as to reduce E_1 to zero at a rate determined by the gain of the servo loop and the integrator time constant. The rate at which E_1 is returned to zero is carefully adjusted to match the response time of the platinum thermometer.

A detailed theoretical description is given in Appendix 7.2.

Fast Response Circuit Description: Compare Fig. 3.1.3(2) with schematic Fig. 5.1.3

A_1 - is op amp IC2/1 and its associated components

M_2 - is IC3, and its associated components

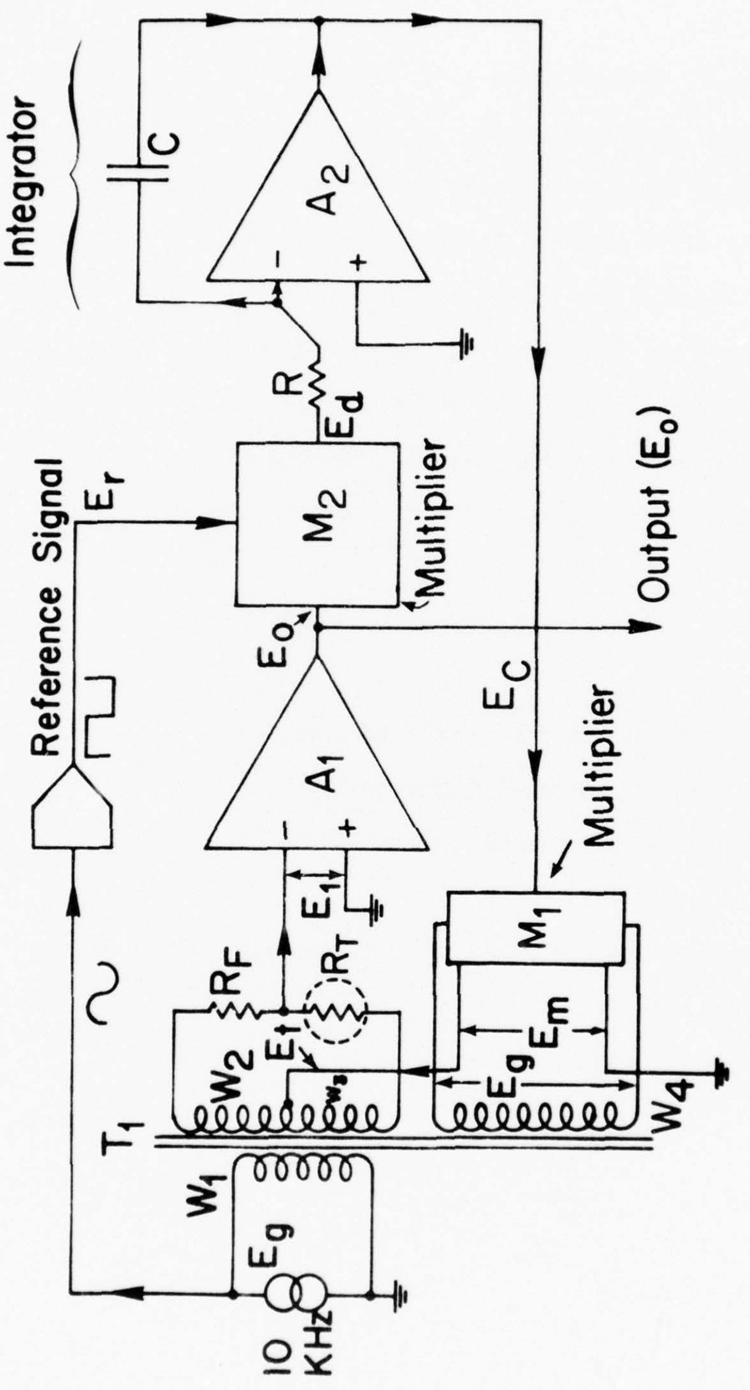
A_2 - is IC4 and its associated components,

R - is R9 and C is C12

IC2/13 inverts the output of A_2, R, C to provide complementary outputs to drive M_1.

Set up instructions for this circuit are given in Section 2.3.

Fig. 3.1.3(2)

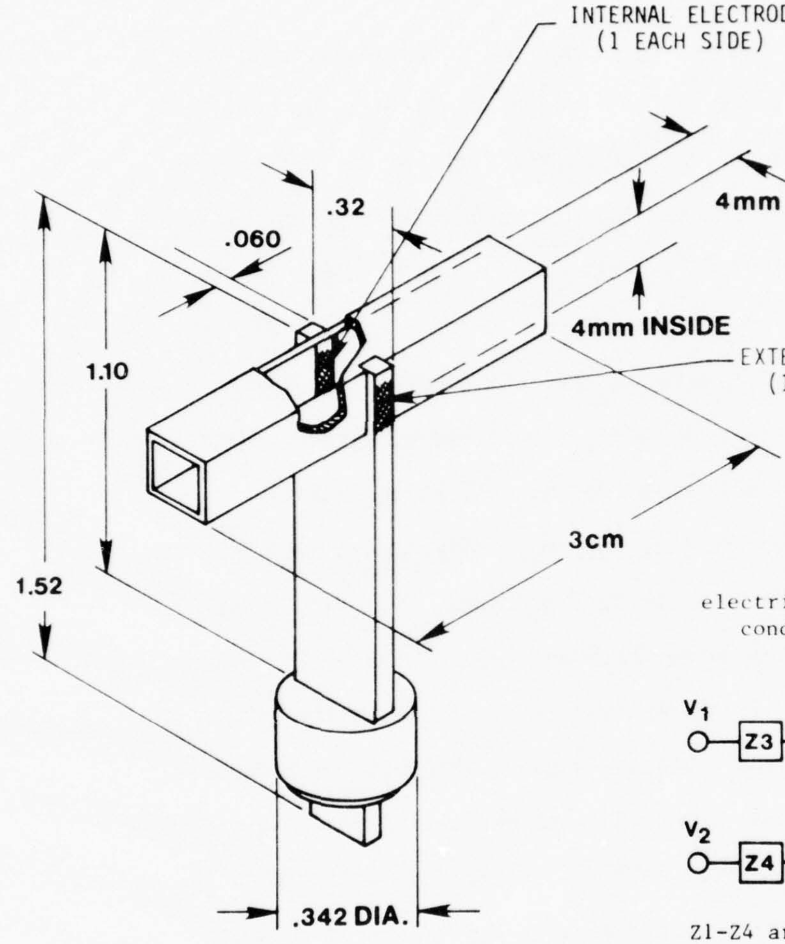


R_T=Fast Response Thermistor

CONDUCTIVITY SENSOR INTERFACE

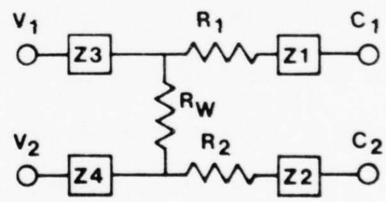
The CTD has a miniature four electrode conductivity cell for measuring sea water conductivity. This type of sensor has the particular advantage that conductance (defined as the ratio of current through the "current electrodes" to the open circuit voltage at the "potential electrodes") is independent of polarization impedance effects. These effects are due to electro-chemical reactions at the electrode-electrolyte interface and are very dependent on surface cleanliness of the electrodes and other factors which make a simple two electrode cell too unpredictable for high accuracy measurements. Unlike an inductively-coupled cell, the four electrode cell can be readily scaled down in size without loss of accuracy due to electrical problems. However, since conductivity is a function of conductance and cell geometry, it should be noted that a small cell is inherently more sensitive to the effect of deposits on the cell wall simply because a given thickness of a deposit represents a larger fractional change in apparent cell dimensions.

The original cylindrical cell was observed to drift at an increasing rate, with the initial rate typically equivalent to .0001 to .0005 parts per thousand salinity per hour of immersion (Fofonoff, Hayes and Millard, 1974). This drift is believed to be due to calcium and/or magnesium carbonate deposits on the inside surfaces of the ceramic structure. A 0.00002 millimeter deposit on the 2 millimeters inside diameter of the microstructure cell causes an apparent change in salinity of approximately .0008 parts per thousand (for S = 35 ppt) due entirely



GENERAL PURPOSE
CONDUCTIVITY CELL
(3cm HEAD)

electrical equivalent of
conductivity cell



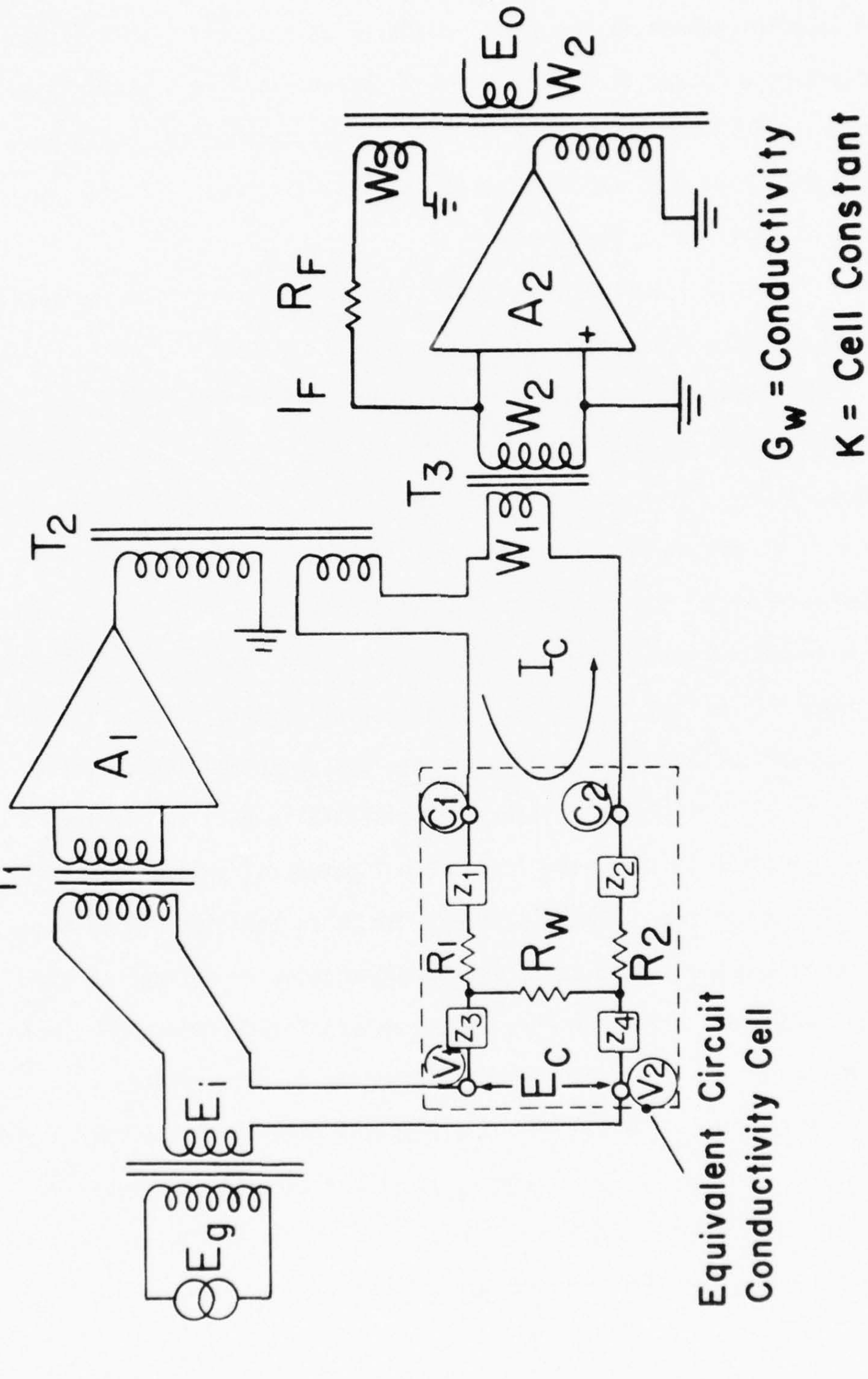
Z1-Z4 are polarization impedance
at each electrode surface

to the apparent change in the inside diameter of the cell. This effect is reduced by a factor of 4 in the general purpose cell now standard on the Mark IIb CTD and calibration is restored by soaking the cell in a solution of 1 part General Chemical Co. Saline Dissolvent diluted with 25 parts of water, for a few minutes.

Figure 3.1.4 shows a cut-away view of the four electrode conductivity sensor and an equivalent electrical circuit of the cell. Two of the four electrodes are opposite each other on the inner wall of a .4cm square ceramic tube 3 cm long. The other two electrodes are mounted externally on the stem; four electrodes are in the same plane normal to the axis of the sensor. This geometry has the advantage of being relatively insensitive to apparent changes in position of the electrodes due to non-uniform contamination. This can be seen from Figure 3.1.4(2) which shows the current flow lines and the resulting equipotential lines in the tubular section of the sensor head. Equipotential lines in the vicinity of the "voltage" electrodes are essentially parallel to the "voltage" electrodes, i.e., the longitudinal potential gradient is very small. This means that a small apparent change in position due to non-uniform contamination would cause negligible changes in voltage at the "voltage" electrode. The symmetry of the external electrodes and their wider separation result in even greater immunity to this effect.

Refering to the equivalent electrical circuit of the cell, Figure 3.1.4, impedences Z_1 through Z_4 are the polarization impedances at each electrode -electrolyte interface . R_1 and R_2 are the sea water path resistances from the "current" electrodes to the points in the

Fig. 3.1.4(2)



Equivalent Circuit
Conductivity Cell
G_W = Conductivity
K = Cell Constant

electrolyte sea water, paths having the same potential as the "voltage" electrodes. R_W represents the remaining sea water path and is measured by observing the ratio of the open circuit voltage across the "voltage" electrodes V_1 and V_2 to the current through the "current" electrodes C_1 and C_2.

$$R_W = \frac{E_C}{I_C}$$

$$\text{so } G_W = \frac{1}{R_W} = \frac{I_C}{E_C} = \text{conductance}.$$

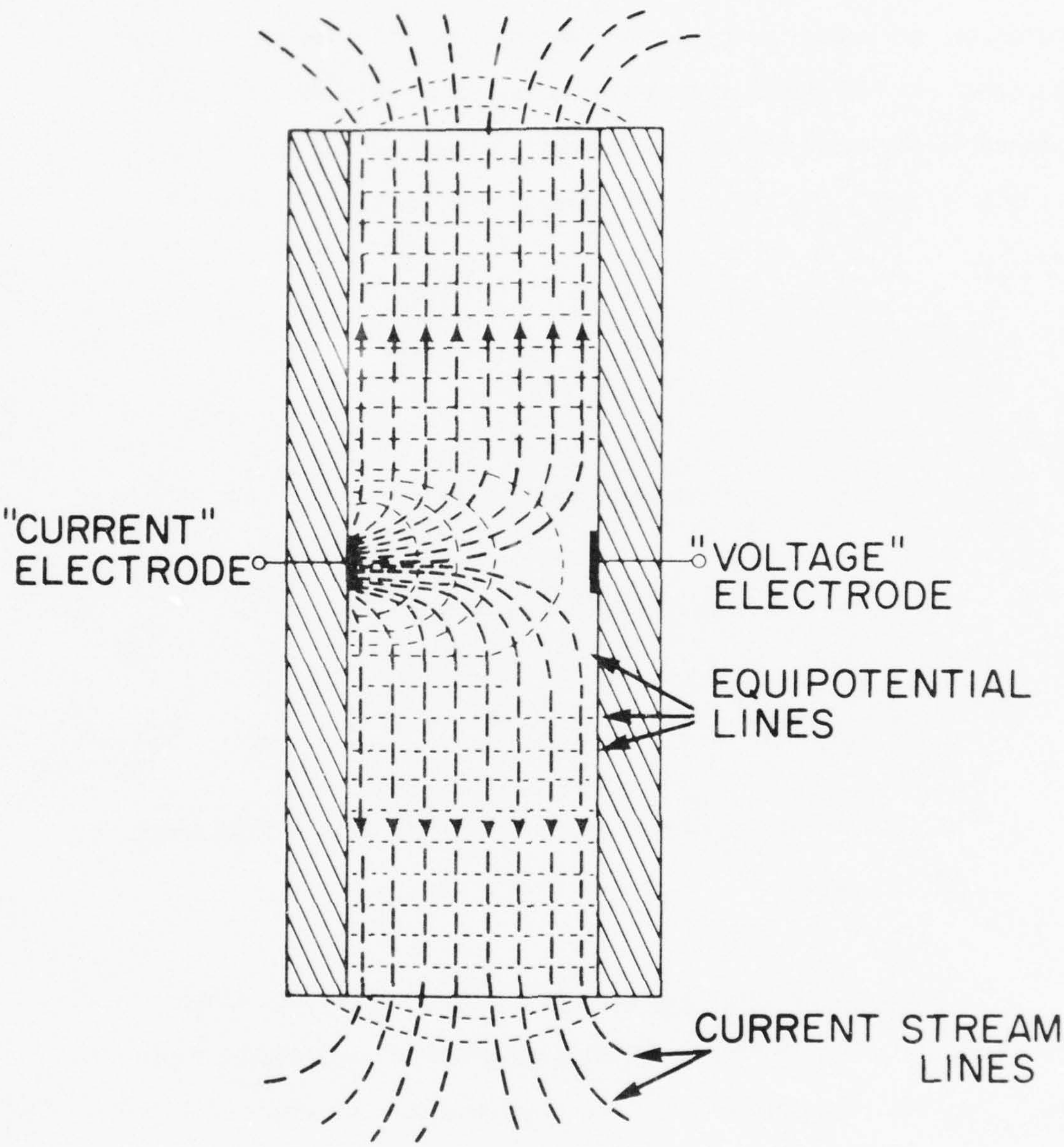
Therefore the conductivity G is given by

$$G = K \frac{I_C}{E_C} = KGw$$

where K = cell constant, dependent on the physical dimensions of the cell.

Conductivity Interface Circuits: The conductivity sensor interface circuit shown in Figure 3.1.4(3) consists of two feed-back circuits. The first consists of the four electrode conductivity cell, transformers T_1 and T_2, and high gain feed-back amplifier A_1. The input signal to A_1 through T_1 is the difference between the 10 kilohertz input reference voltage E_i and the voltage across the voltage electrodes V_1 and V_2 of the conductivity cell. Assuming A_1 has infinite gain and the feed-back is negative, then the voltage E_C will be exactly equal to input

Fig. 3.1.4(3)


"CURRENT"
ELECTRODE
"VOLTAGE"
ELECTRODE
EQUIPOTENTIAL
LINES
CURRENT STREAM
LINES

reference E_i, since

$$E_c = I_c R_w = E_i$$

$$I_c = \frac{E_i}{R_w}$$

$$= E_i G_w$$

where G_w = conductance of sea water path.

The cell current I_c is applied to the input transformer T_3 of the second feed-back circuit which consists of T_3, A_2, output transformer T_4 and feed-back resistor R_f. Negative feed-back through A_2 and T_4 will result in a feed back current I_f through winding W_2 on T_3 such that

$$I_f W_2 = I_c W_1 \quad (W_1, W_2 \text{ on } T_3) \text{ and } I_f = I_c \left(\frac{W_1}{W_2}\right)$$

now $E_o = I_f R_f$

$$= I_c R_f \left(\frac{W_1}{W_2}\right) \text{ but } I_c = \frac{E_i}{R_w} = E_i G_w$$

$$= E_i G_w R_f \left(\frac{W_1}{W_2}\right) \text{ if } G_w = gK, \text{ then}$$

$$E_0 = gKE_i R_f \left(\frac{W_1}{W_2}\right) \quad \frac{E_0}{E_i} = gKR_f \left(\frac{W_1}{W_2}\right)$$

$$\text{therefore } \frac{E_o}{E_i} = gK_1$$

therefore $\frac{E_o}{E_i} = gK_1$

where $K_1 = KR_f(\frac{W_1}{W_2})$, a circuit constant.

The ratio of the conductivity interface circuit output voltage to input reference voltage, $\frac{E_o}{E_i}$, is proportional to the conductivity, g, of the sea water inside and immediately around the conductivity cell.

The current source A_1 which drives a current through the conductivity cell in order to generate a voltage E_c equal and opposite to E_i is made up of the components labeled "Conductivity to Current Converter" between transformers T1 and T2 on the Conductivity interface schematic. The current that is driven through the cell also excites the primary winding of T3. A second amplifier A_2 labeled "current to voltage Amp." is made up from the components between transformers T3 and T4. The plug-in feedback circuit R_f is a very stable resistor network made up of components P2, R10, R11, and R17, and determines the thermal stability of this interface. Zero offset and quadrature errors are nulled using potentiometers P1 and P3.

Unlike the Pressure and Temperature circuits the output of the conductivity circuit is unipolar, and the analog gate is selected by the select conductivity signal independent of S_o and $\overline{S}_o$, the sign signals.

OXYGEN INTERFACE (OPTIONAL)

Optionally, the MarkIIIb CTD/O provides an electrical interface to the Beckman polaragraphic dissolved oxygen sensor (Beckman p/n 147737 sensor, p/n 148184 sensor receptacle assembly). By means of this the electrode membrane current and sensor thermistor outputs are digitized and added to the CTD serial data stream. Sensor membrane current is presented at full scale value of 2.047 μA and 12-bit resolution, while the thermistor output is linearized and offset to allow resolution of approximately 0.13 degrees C. Temperature information is presented as an 8-bit signed binary word having values between -15 and +241 corresponding to temperatures between -1.9 and +30.8 degrees C. Both O_2 membrane current and O_2 thermistor resistance are averaged by the electronics for 1.024 seconds.

Oxygen Sensor: The Beckman oxygen sensor is polarized at 0.81v $\pm$ 0.02v by the Mark IIIb CTD interface electronics. The O_2 dependent sensor current is digitized by means of a current-to-frequency converter, the output of which is counted for 1.024 seconds. The counter output is thus a binary word with a value proportional to sensor current. The zero drift and linearity of this conversion are maintained within $\pm$1/2 LSB. The gain accuracy, i.e., full-scale current, is maintained $\pm$ 0.1% $\pm$ 100ppm/degree C. This is sufficient to hold errors in the electronics an order of magnitude below sensor uncertainties.

Other full-scale current ranges for membrane current may be chosen by making $R5 = 2.5/I_s$ where I_s is the desired full-scale. R5 should be

a type RN60C of 1% value nearest the calculated resistance.

MEMBRANE TEMPERATURE: The Beckman sensor receptacle assembly incorporates a thermistor which allows an approximate determination of the internal membrane temperature. The Mark IIIb CTD interface electronics provides an 8-bit digitization of thermistor resistance. The accuracy of this conversion is such that an absolute determination of thermistor resistance to within 1 part in 2^8 may be obtained by means of the following relationship:

$$R_t = \frac{1}{mx + b} - R_s$$

where

R_t is thermistor resistance at T

m & b are calibration constants

x is the binary output of the temperature channel, with sign

R_s is the value of a resistor used to optimize the temperature channel resolution and linearity

The calibration constants may be determined as follows:

$$m = \frac{\dfrac{1}{R_T + R_s} - \dfrac{1}{R_{To} + R_s}}{240}$$

$$b = \frac{1}{R_{To} + R_s}$$

where R_T is the thermistor resistance at 30.72 degrees

R_{To} is the thermistor resistance at 0 degrees C

R_s is the linearization resistor defined above

The value 240 in the equation for m represents the difference between the digitizer output at 30.72 deg. and zero. The authors generate a table of R-T values for each sensor by making three accurate measurements

of thermistor resistance ($\pm$0.1%) at three temperatures (approximately 0, 15, and 27 degrees C, absolute value within 0.01 degrees C). These values determine coefficients for a second order exponential equation which fits the range -2 to +31 degrees C within 0.0015 degrees C. The equation generates a table of R-T values spanning the calibration range of the interface. The electronics is then calibrated with a precision ($\pm$0.01%) resistance decade box simulation of the tabulated thermistor resistance values.

The binary output of the temperature channel is multiplied by 2^7 and divided by 1000 in the CTD Data Terminal number converter. This results in a displayed temperature range of -1.9 to +30.7 degrees C. The temperature channel is calibrated by adjusting the interface electronics at 0 and 30.72 degrees C.

The maximum deviation from predicted temperature is approximately 0.25 degrees C, with zero error at 0, 30.7 and half-scale.

Data Format: The O_2 membrane current is represented as a 16 bit word with the 4 most significant bits unconditionally set to zero. The 8 least significant bits are available at bit time 98, while the 8 most significant bits occur at bit time 109. The temperature channel output is the 8 bit word occurring at bit time 120. The O_2 temperature sign is the third least significant bit in the sign word. The sign word occurs at bit time 087.

Power supply: Transformer T1 and diodes D1 through D4 with transistor Q1 form a floating d.c. power supply permitting the oxygen sensor to be powered without forming an electrical path to the CTD

housing. All logic signals between the d.c. digitizer and the remainder of the CTD circuitry are smiliarly ac coupled. This power supply generates approximately 10 volts across the diode bridge.

Oxygen Interface: The oxygen interface consists of two dc digitizers, one 12 bit and one 8 bit. These digitizers operate on a charge balancing technique. A counter stores the number of pulse of a fixed frequency which are required to produce an average current through a resistive network so as to exactly balance an unknown current for a given sampling time(1.024 seconds). Controlled reference voltage is applied to the polargraphic oxygen sensor and a thermistor. The resulting currents which are a function of dissolved oxygen and sensor membrane temperature are input to the digitizers. The digitizer output is a 12 bit digital number proportional to the current between the polargraphic sensor electrodes when a dc reference voltage is applied to them. The interface also digitizes to 8 bit resolution the current through a thermistor in the same sensor assembly when the same dc reference voltage is applied to it. These two numbers are used to compute dissolved oxygen by an appropriate algorithm.

Operational amplifier IC2 is wired as an integrating comparator which balances the O_2 sensor current and the average current through resistors, R5 and P1. Output D of flip-flop IC5/1 is initially set low and the current source for R_5 and P_1 becomes the negative supply. When the average current from this source is sufficient to null the integrated input to the comparator then D of IC5/1 is set high and the current in R_5 and P_1 is switched off. The length of time during which the current source is the negative supply is measured by gating

a 4 kHz clock into counter IC9 with $\overline{Q}$ of IC5/1. If the maximum sensor current is flowing then $\overline{Q}$ of IC 5/1 will be true for the entire 1.024 seconds sensor averaging time producing a maximum output of 4096 counts which is displayed as 2.048μA.

The temperature digitizer (IC3, IC5/13, IC4/13, IC4/12, IC6/5 & 14, IC11/13 & 10,) behaves in the same manner, except the zero is offset by summing a steady current from R6, R7 and P2 into the integrating comparator, IC3. In this case the maximum count will be 256 and a 250 hz clock is used. To provide bipolar output capability the circuit is arranged so no current flows through the thermistor at -1.9°C. The gated counter in this case combines a presetable count-down/count-up counter and a binary counter. Initially the up-down counter is set to 15 in the count down mode; when this counter reaches zero it is set to count up and the sign bit is set positive. Overflow from the counter is counted by the binary counter. The temperature channel has a minimum count of -15 and a maximum count of 241 and is displayed using E15 enable : 10^3; the oxygen temperature is displayed on the deck unit over a range of -1.9°C to +30.7°C.

IC7, IC8, IC11/1, IC12 and IC13 control the timing of the data transfer into the telemetry register.

POWER SUPPLY - UNDERWATER

The input to the underwater unit power supply is unregulated dc from the deck unit which a zener diode mounted on the underwater unit card rack end plate limits to 22 volts. The regulated outputs are a low impedance 12 volt $\pm$ 5% supply with current limiting at approximately 120 mA and a 6 volt supply which is adjusted by a potentiometer to be equal to one-half the nominal 12 volt output $\pm$ .01 volts and current limits at approximately 40 mA.

Transistor Q3, diodes CR1, CR2, CR3 and resistors R10 and R19 form a constant current circuit which turns the darlington pair Q4 and Q5 hard on. The Q5 collector current flowing through CR5 and R15 generates a voltage across R15 which turns on Q7 causing it to pass current from the constant current source and adjust the zener current of CR5 to approximately 3mA. The collector current in Q5 is limited to about 120mA by R11 and Q6. When 120 mA is flowing through R11, Q6 turns on causing Q7 to conduct more current and starve the base of Q4. The maximum available 12 volt output current will therefore be 120 mA less the 3mA zener current and equal to 117 mA.

The output voltage is the sum of the CR5 zener voltage and the voltage drop across R15 or 12.3 volts, $\pm$ 10%.

The 6 volt supply is generated by regulator IC1. The level is adjusted by variable resistor, R6 and fixed resistors, R5 and R7. The current limit is set at 43 mA by resistor R9.

Transistors Q1 and Q2 with their associated resistors and diode perform no function in the standard Mark IIIb CTD, but are used only when the system is operated with a battery pack; Q1 is normally replaced by the jumper indicated by a dotted line.

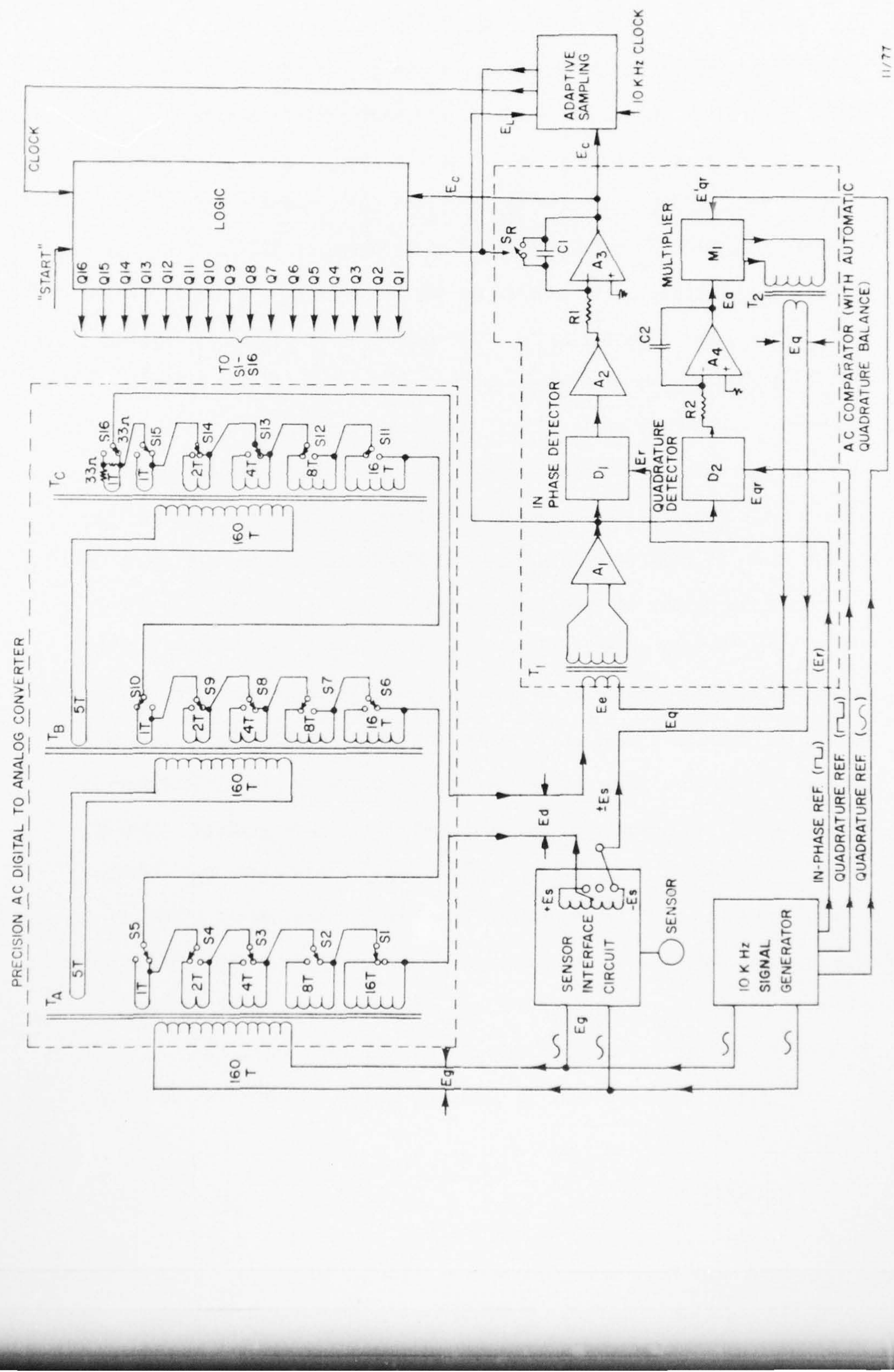
AC COMPARATOR

The purpose of the AC comparator is to detect if the 10 kHz D/A output is greater than or less than the sensor interface signal. Referring to figure 3.1.7, assume initially that E_s and E_d are exactly in phase and that $E_q = 0$. The input E_e to the comparator is the difference between E_s and E_d and will be in phase or 180° out of phase depending on whether E_s is greater or smaller than E_d. E_e is amplified by T_1 and A_1, and detected by D_1. The resulting dc signal is further amplified in A_2 and then applied to the input of a "finite time" integrator consisting of A_3, R_1, C_1 and reset switch S_R. S_R is momentarily closed, re-zeroing the integrator at the beginning of each clock pulse to the logic module. The dc error signal including random noise at the output of A_2 is then integrated for the remainder of the clock period and the resulting output is then interpreted by the logic as either "high" or "low". The "finite time" integrator is thus used as an optimum filter having no "memory" of the error signal during the previous clock period so its response to a very small error signal is not impared by having been subjected to a large error signal during the previous clock period.

Initially we assumed E_q was zero and that E_s was exactly in phase with E_d. In reality, there is usually a small phase difference between E_s and E_d due to a small quadrature component in the sensor signal E_s. The in-phase detector D_1 theoretically should not be sensitive to a small quadrature component. However, if the quadrature component is large enough D_1 can saturate causing non-linear operation and error.

Any quadrature component is detected by the "quadrature" detector

Fig. 3.1.7


PRECISION AC DIGITAL TO ANALOG CONVERTER
"START"
LOGIC
CLOCK
10 KHz CLOCK
ADAPTIVE SAMPLING
TO S1-S16
IN PHASE DETECTOR
QUADRATURE DETECTOR
MULTIPLIER
AC COMPARATOR (WITH AUTOMATIC QUADRATURE BALANCE)
SENSOR INTERFACE CIRCUIT
SENSOR
10 K Hz SIGNAL GENERATOR
IN-PHASE REF.
QUADRATURE REF.
QUADRATURE REF.
160 T
5T
11/77

D_2 which is identical to D_1 except that its reference. E_{qr} is phase shifted 90°. The output of D_2 is filtered in a second integrator consisting of R_2, C_2 and A_4. The filtered output is then applied to one input of a multiplier M_1; a second input to $M_.$ is a 10 kHz sine wave shifted 90° from the sensor input E_q. This means that the resulting output from M_1 is at 90° or 270° depending on the polarity of E_a. The closed loop consisting of T_1, A_1, D_2, A_4, M_1 and T_2 automatically balances the quadrature component of E_e by making E_q exactly equal and opposite to it.

Compare fig. 3.1.7 with the detailed schematic fig. 5.1.7

A_1 is op amp IC1/1 and associated components

D_1 is op amp IC1/13 and associated components (see appendix 7.5)

A_2 is op amp IC2/1 and associated components

A_3, R_1, C_1 - finite time integrator - is op amp IC3, R19, C7 and other associated components.

D_2 is op amp IC2/13 and associated components.

A_4, R_2, C_2 - finite time integrator - by op amp IC4, R32, C10 and other associated components

M_1, - multiplier - is IC5 and associated components

S_R - Comparator reset switch is implemented with IC6/10.

Examples of typical wave forms for the comparator test points are included in Section 2.4.

DIGITAL TO ANALOG CONVERTER

The digital to analog converter is a digitally controlled ratio transformer. The precision of the input to output ratio is better than 1 part in 10^5, an accuracy which is unattainable using conventional current summing converters. These devices are subject to uncertainties caused by finite switch resistance and imprecise resistors having significant temperature coefficients and long term drift.

The theory and practice of precision ratio transformers is widely documented and will not be discussed here except to note that the use of very high permeability cores (e.g., Supermalloy), proper selection of operating frequency, winding geometry, and shielding etc., result in transformers having output voltage ratios precisely proportional to the turns ratios. In special cases the precision can be as high as 1 part in 10^8.

Each of the three transformers T_A, T_B and T_C have a 16, 8, 4, 2 and 1 turn windings, i.e., five binary stages. T_C has an additional 1 turn winding with a resistive divider to provide the 16th binary stage (LSB). A 5-turn winding on T_A drives a 160-turn winding on T_B giving a 32 to 1 reduction from T_A to T_B. Similarly, a 160-turn winding on T_C is driven from a 5-turn winding on T_B.

Each switch S_1 through S_{16} is single pole-double throw and is implemented by a pair of FET's. One switch of each pair is turned "ON" or "OFF" directly by one line (Q_1 through Q_{16}) from the logic module while the other is turned "OFF" or "ON" by inverting the logic output.

Experience with this type of AC D/A Converter has consistently shown very nearly ideal performance with total errors less than 1 least significant bit and no detectable drift.

The digital to Analog Converter plays a critical role in the accuracy of the digitizer section of the CTD, shown in simplified diagram Figure 3.1.7.

DIGITIZER LOGIC

The digitizer logic circuit uses Motorola successive approximation registers and is in a loop including a D/A converter and a comparator to generate from a given input signal a binary number which precisely represents the input signal.

Digitization is initiated by a "START" command to the logic module causing S_0 to be set "high" and S_1 through S_{16} to be set "low". The A/C comparator compares the analog output from the D/A converter E_d with the sensor output voltage E_s. If E_s is smaller than E_d, with S_1 through S_{16} low, E_d equals zero and the comparator output E_c goes "low". At the next clock pulse S_0 is set "low", indicating a negative sign and reversing polarity of E_s; S_1 is set "high". If E_s is larger than E_d, E_c goes "high" and then at the clock pulse S_0 remains "high" and S_1 is set "high". This sequence is repeated until switches S_0 through S_{16} have been set by logic outputs Q_0 through Q_{16}. At this point the analog output of the D/A converter E_d is equal to the sensor output E_s. The binary output is represented by the settings of Q_0 through Q_{16}.

The Motorola successive approximation registers (S.A.R.) are IC1 and IC3 and the timing diagram for them is shown in fig. 3.1.9.

1) A "master reset" (M.R.) pulse will cause all outputs to go low.
2) A "start convert" (S.C.) pulse will arm the device so that the succeeding clock pulse will start the successive approximation.
3) The first clock pulse sets Q_0 high and Q_1 thru Q_7 low

AD-A052 054 WOODS HOLE OCEANOGRAPHIC INSTITUTION MASS F/G 8/10
W.H.O.I./BROWN CONDUCTIVITY, TEMPERATURE, AND DEPTH MICROPROFIL--ETC(U)
FEB 78 N L BROWN, G K MORRISON N00014-66-C-0241
UNCLASSIFIED WHOI-78-23 NL

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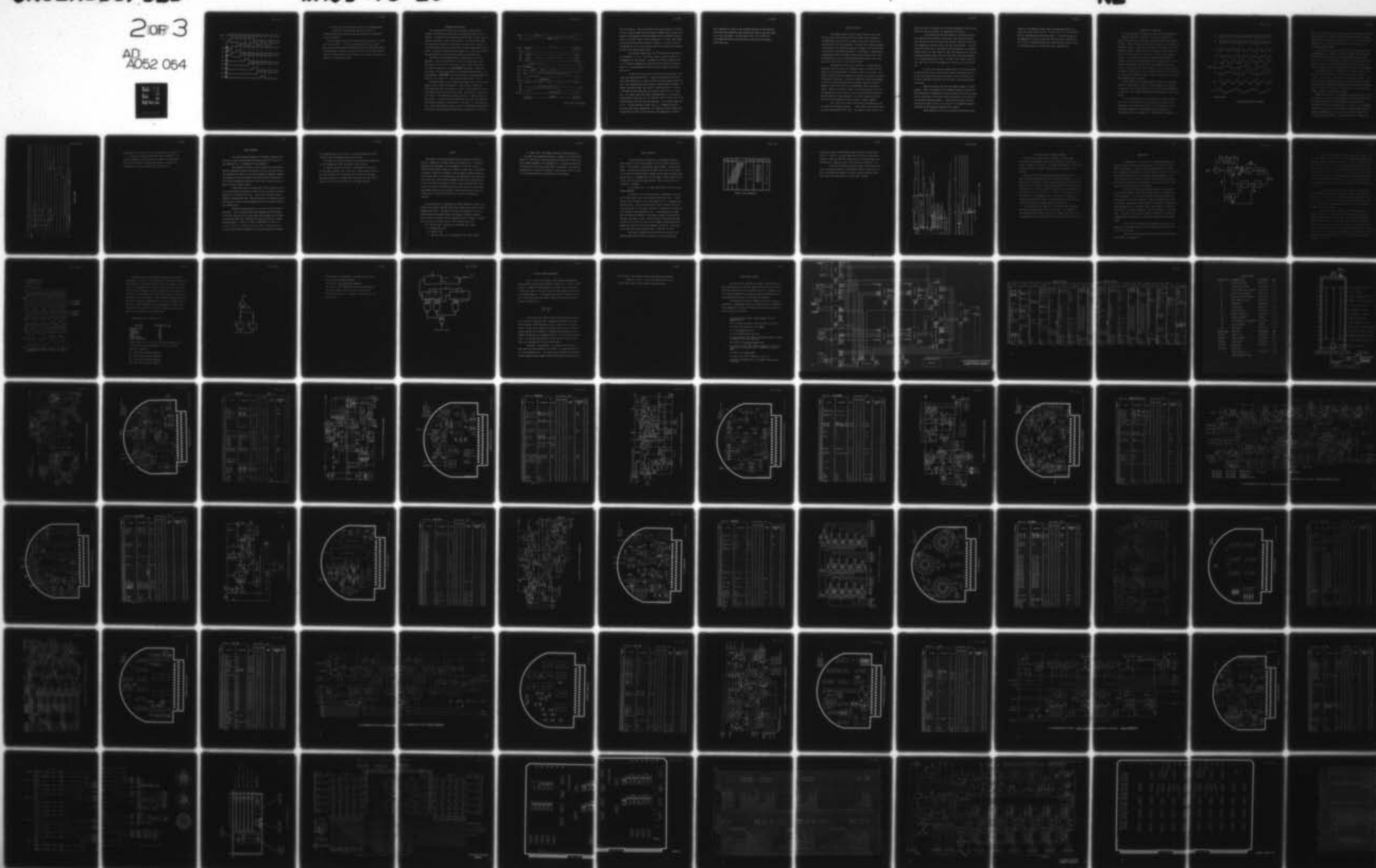
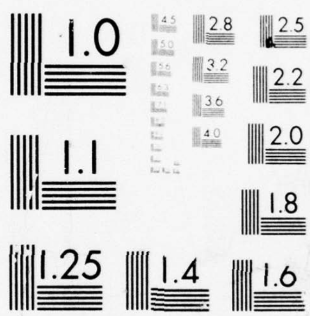
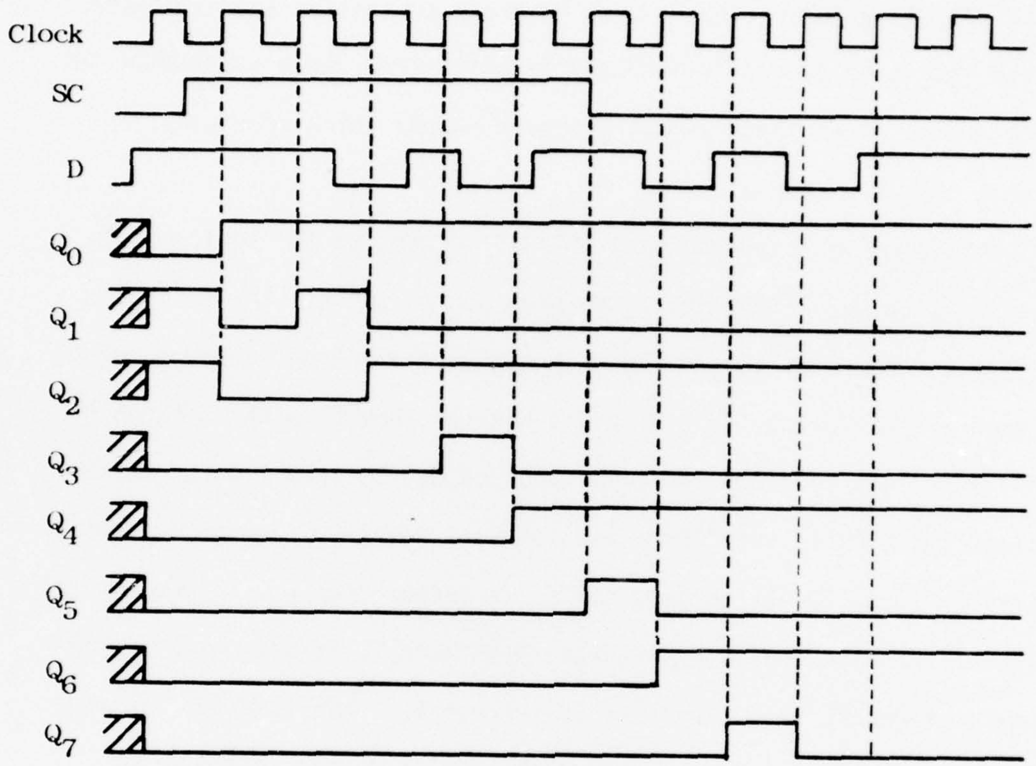
AD
A052 054





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Fig. 3.1.9



4) The next clock pulse leaves Q_0 high or not, depending upon state of D; and unconditionally sets Q_1 high, etc.

In the digitizer logic circuit two of these devices are cascaded for 16 bit digitization.

An extra stage to the S.A.R. which determines the sign bit is made up of IC5 and IC6/13. Flip-flop, IC6/2 generates the Q_{16} waveform which tells the memory and multiplexer to select the next analog channel for digitization. Registers IC2 and IC4 are part of the long telemetry register; following the third digitization in any frame, the conductivity value will be strobed into them.

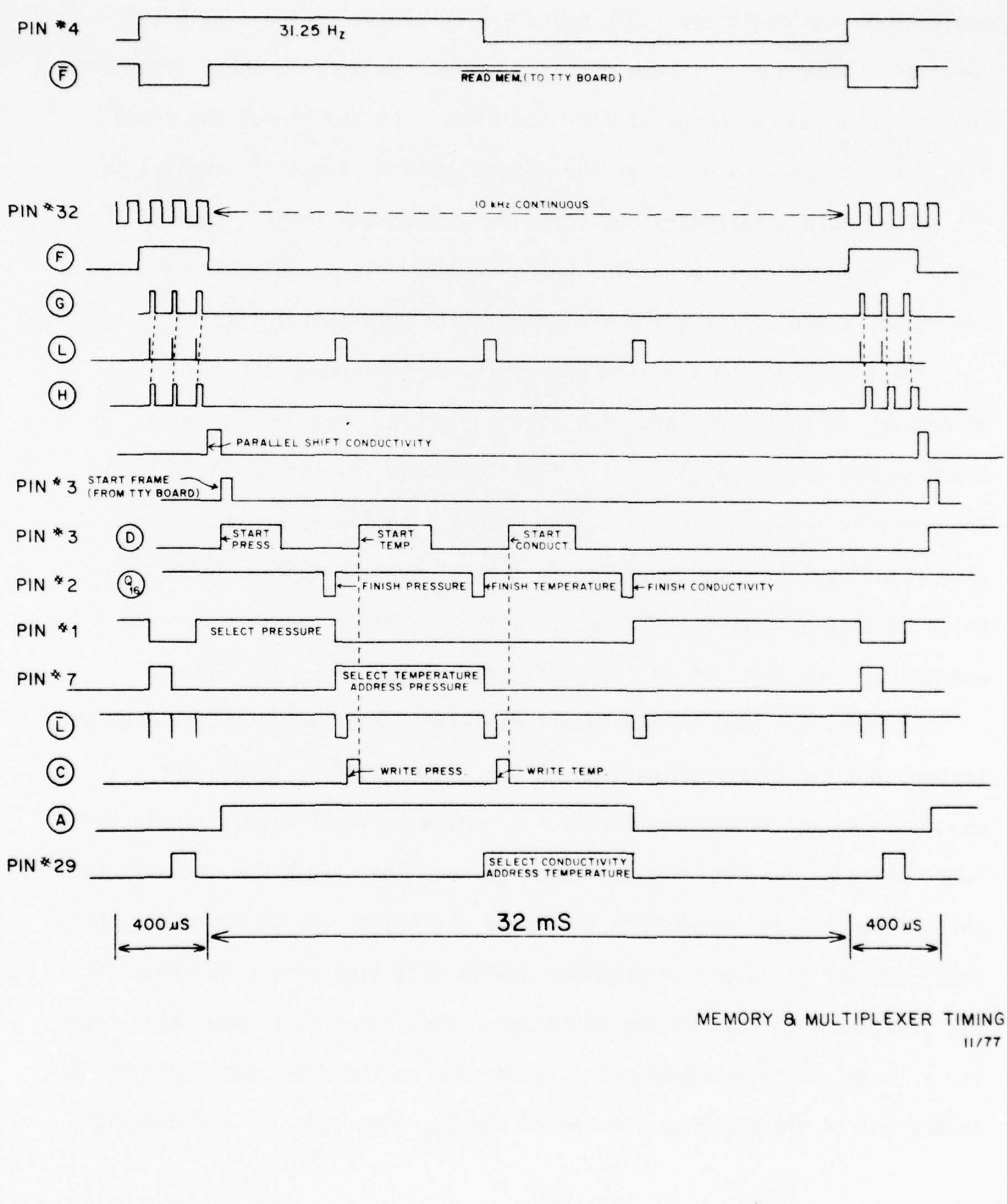
MEMORY AND MULTIPLEXER

The sixteen parallel outputs of the successive approximation register on the digitizer logic board are connected to two 4 by 8 bit memories. At the end of each sampling period the data on these lines are shifted into memory in one of four locations. At the end of the frame time the data are moved out of the memory and into a set of parallel input serial output telemetry registers for coding and transmission up the cable. In addition to providing buffer memory this circuit also controls the multiplexing of the three analog channels into the digitizer.

The timing of the sampling process is controlled by the signal generator. A positive transition of the 31.25 Hz square wave causes the $\overline{Q}$ output of the 'finish' flip flop' to pulse low for about 300 μs. The positive transition of this $\overline{\text{READ MEMORY}}$ line causes a 'start digitize frame' pulse to be generated in the Teletype formatting board. The delay between a '$\overline{\text{READ MEMORY}}$' positive transition is variable between 200 and 400 μs; the duration of 'start digitize frame' pulse is 200 μs.

The positive edge of the 'start digitize frame' pulse sets the reset, status, and the filter flip-flops (FF). The reset F.F. resets the word counter and clocks the status F.F. which is still being held in the 'set' state by the 'start dig. frame' pulse. The status F.F. remains set until after all the parameters have been digitized. On being reset, the word counter '0' output or pressure analog gate line goes high connecting the pressure interface to the digitizer. The filter F. F. goes high causing a 'start digitize word' pulse to be sent to the digitizer logic board. At the end of the digitization period the Q_{16} line goes low for one digi-

Fig. 3.1.10



MEMORY & MULTIPLEXER TIMING

11/77

tizer clock period. The positive edge of this pulse causes a 3 μs pulse on line L, which advances the word counter to operate the next gate, temperature, simultaneously telling the memory that the digitized pressure data on its parallel input is to be called word 1. As the L line reverts to the low state the positive edge of $\overline{L}$ causes a 3 μs 'write' pulse to be generated on line C and the ensuing positive transition of $\overline{C}$ generates the next 'start digitize word' pulse.

This process repeats unitl the n^{th} word has been digitized (n is selectable 2, 3, or 4). The n^{th} Q_{16} causes L to pulse high for 3 μs incrementing the 'word counter' to address the n^{th} word, operating the $(n + 1)^{th}$ gate and immediately resetting the word counter and setting status F.F. low preventing any further writing to memory by disabling the write F.F.

On the arrival of the next 31.25 Hz positive transition, line F goes high enabling the Read F.F. Positive transitions of the 10 kHz clock signal generate 10 μs pulses on the G line which appear directly on the L line incrementing the word counter to address memory locations. To address the pressure word, the rise of $\overline{L}$ clocks the write F.F. but the C line does not get pulsed since the D input of the write F.F. is now low. 10 μs after G goes high $\overline{G}$ goes high generating a 2 μs pulse on H which parallel shifts data from the addressed memory location into the addressed parallel-in serial-out shift registers. This process repeats until (n - 1) words have been shifted into (n - 1) telemetry registers. The final word, always conductivity, will remain on the D/A output until $\overline{F}$ goes high at the end of the frame time, thus generating a 'parallel

shift conductivity' signal in the Teletype formatting circuit which parallel-shifts the conductivity data from the D/A input to the shift register on the logic board. The logic board sends a start frame back to the memory multiplexer board and both digitization and telemetry cycles start over.

ADAPTIVE SAMPLING

The adaptive sampling circuit varies the clock rate to the digitizer logic and the reset time of the 'finite time' integrator in the comparator in such a way as to obtain a minimum digitization time consistant with error free operation. The reset time is 600 microseconds if the previous error signal was equal to or greater than the sixth most significant bit, and 200 microseconds if it was smaller. The 600 microseconds period allows an automatic quadrature balancing circuit in the AC Comparator more time to recover from saturation effects which occur when large signals exist at the comparator input.

The adaptive sampling circuit contains a threshold detector which goes 'high' as soon as the comparator output, a finite time integrator, falls to approximately +2.5 volts or rises to +9.5 volts. This causes a D type flip-flop to generate a digitizer clock pulse at the next 10 kHz master clock pulse. Large error signals will cause the comparator to arrive at a decision rapidly and the adaptive sampling circuit will generate a clock within 100 μs of the comparator reset line being released. However, if the error signal is sufficiently small or zero and the comparator has not arrived at a decision after one millisecond the adaptive sampling circuit generates a clock pulse without waiting for the finite time integrator to reach the upper or lower threshold.

This circuit also contains the Pressure and Temperature sign bit latches and telemetry register, strobe signals used to latch these two signs are generated on this card. They appear on pins 29 and 31 and

they are useful for triggering an oscilloscope immediately after the completion of either the Pressure or Temperature digitizations.

At the beginning of the digitization of a new word the adaptive sampling circuit receives an A/S reset signal from the digitizer logic, which sets IC2/13 and arms IC5/13 causing a digitizer clock pulse to be generated at the next 10 kHz clock positive transition. The digitizer clock causes IC2/1 to be clocked and the comparator to be unconditionally reset. For every digitizer clock pulse except the one initiated by adaptive sampling reset, IC2/1 will latch the signal from comparator T.P.1 during the previous bit time. For small error signals during the last step, IC2/1 Q will be set high but for large errors it will be set low.

As this first clock pulse resets IC2/1 it will disable IC8/11 so that the reset time for the first bit time will be forced to 600 μs. For the first step then we have to wait 600 μs for IC9 to count up to 5 since it was held in reset for the first 100 μs during the digitizer clock pulse.

When the digitizer reset has been removed counter IC1 starts counting. Either IC1 counting to 9 or threshold detector (Q4, Q12, Q3 and Q4) detecting a threshold will cause the arming of IC3/13 so the next positive transition of the 10 kHz clock will generate a clock pulse and the following transition remove it. The digitizing time for each bit then may be as short as 300 μs or as long as 1.6 ms depending upon the magnitudes of the present and previous error signals.

Normal operation of this circuit may be ascertained by exam-

ination of the comparator output signal (see waveforms section 2.4) - reset times should always be 600 μs for the first step in a digitization but will subsequently be either 200 or 600 μs. The time required for the comparator to arrive at a decision after the reset is removed will vary in 100 μs increments between 100 μs when the error signal is large to 1ms when the error is less than one least significant bit.

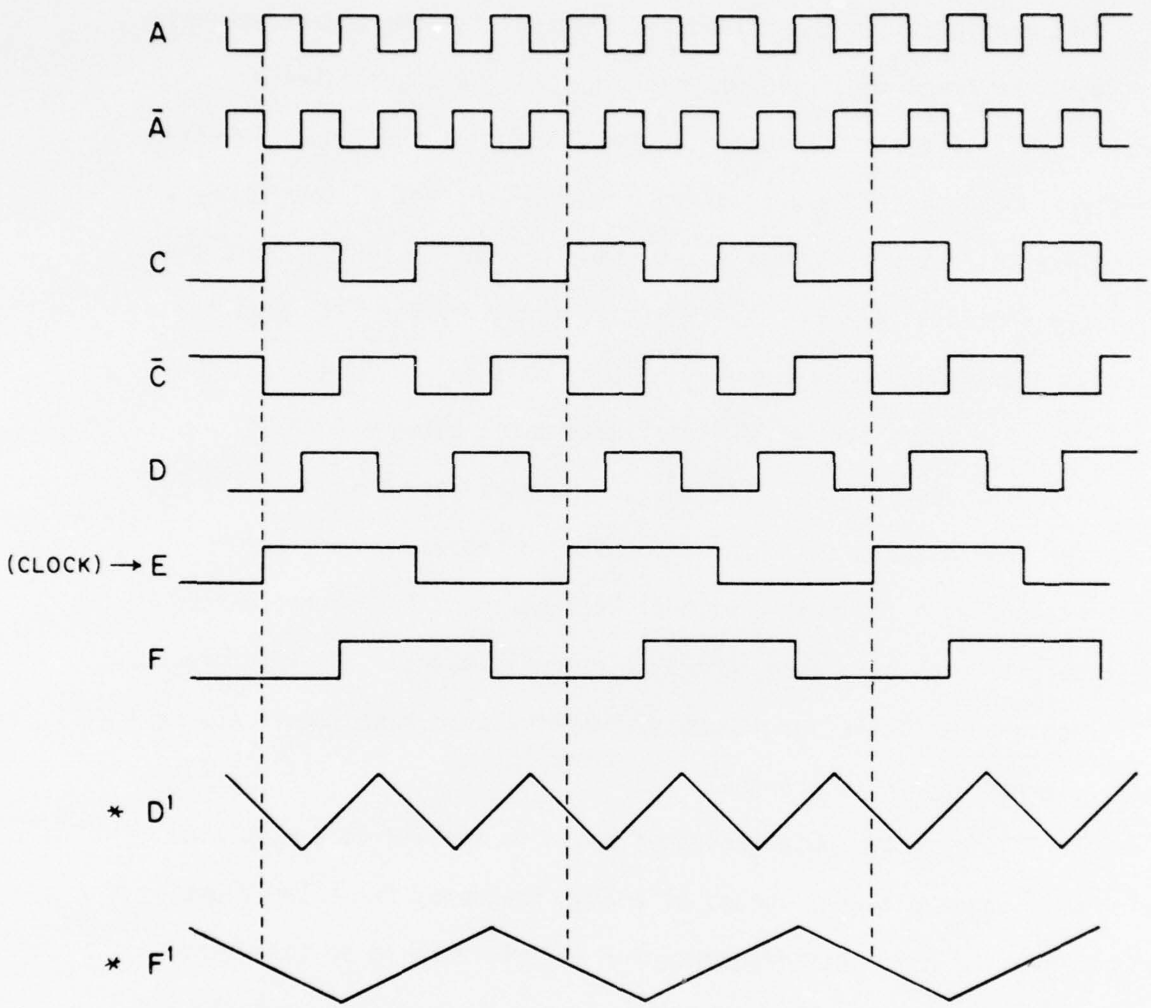
TTY FORMATTER & FSK MODULATOR

This card provides the telemetry circuitry for the underwater unit. When the "read mem." signal goes high this card generates a parallel shift signal that completes the loading of the long telemetry register. Other sections are loaded under the control of the Memory and Multiplexer circuit. Internally this parallel shift signal starts the telemetry process; a zero "start" bit is output by the TTY formatter which is then followed by the first 8 bits of data in the telemetry register. The frame sync word always alternates between 00001111 (decimal, 015) and 1111 0000 (decimal, 240) on adjacent scans. The TTY formatter then outputs two "one" stop bits followed another "zero" start bit and then the next 8 bits of data etc. until a preset number of eight-bit bytes have been sent as eleven-bit words. The TTY formatter will then send a continuous stream of "ones" (logic high) until the next data telemetry cycle is started.

The TTY formatted data generated above is applied to a modulator which will cause either 2 cycles of a high frequency for a logic one or one cycle of half that frequency for a logic zero to be telemetred up the cable. In a standard system these two frequencies are 5 kHz and 10 kHz.

IC's 1 and 6 produce a 40 kHz clock which is further divided by ICs 2 and 3 to produce two 5 kHz square waves phase-shifted by 90° designated F and in-phase data clock K. A third output is a 10 kHz square wave designated 2F, phased such that zero crossings of F correspond with zero crossings of 2F. The data clock is gated, with

Fig. 3.1.12



* NOT TO SCALE

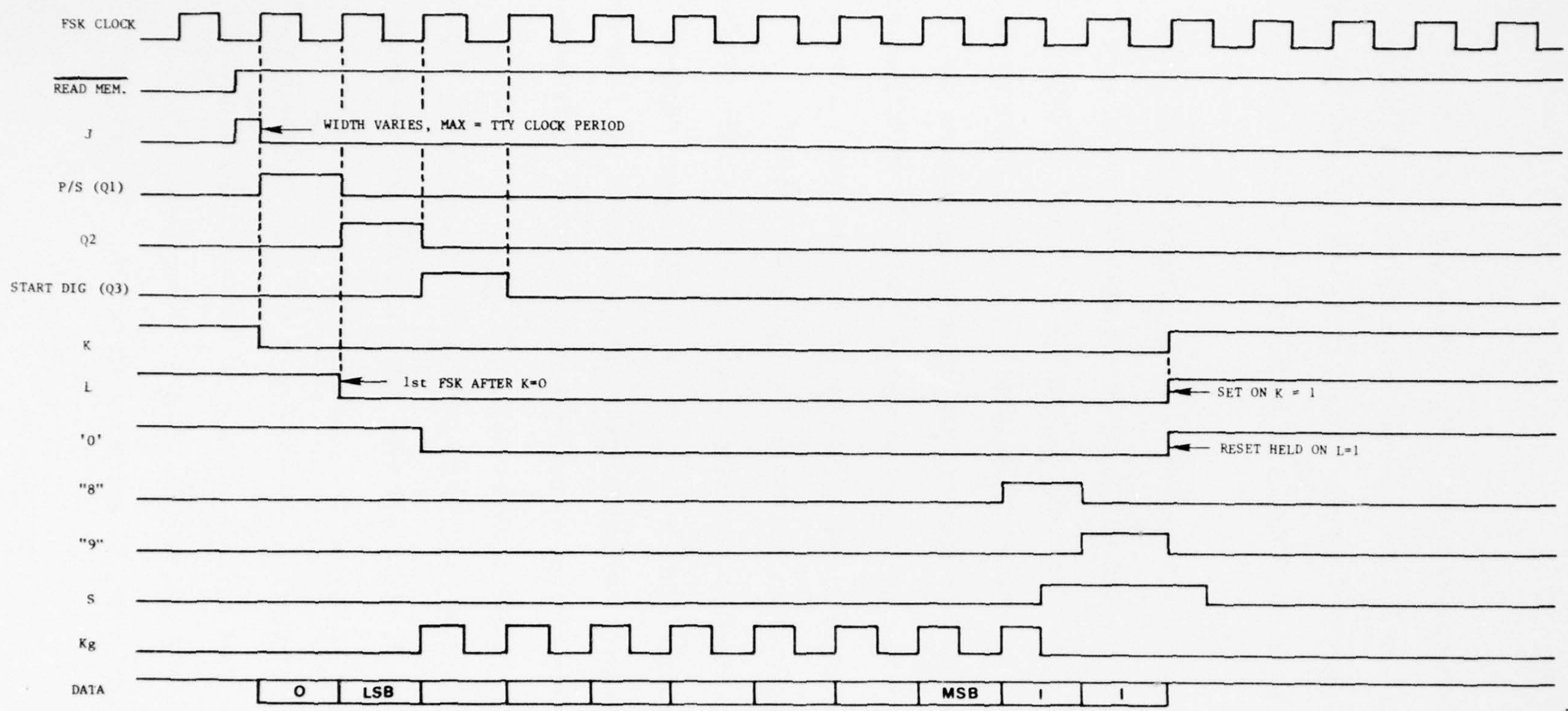
FSK MODULATOR TIMING DIAGRAM

ICs 7, 10, 12 and 13;for every 8 data shifts there are three gaps in this clock stream as it is applied to the long telemetry register. During these gaps in the gated clock stream, ICs 6, 7, 10, 12 & 13 utilize the ungated clock, K to blend the "one" stop bits and "zero" start bit into the output data stream.

IC9/1 toggles on "parallel shift" signals alternating the frame synchronization word applied to the shift register IC8 at the head of the long telemetry shift register between 00001111 and 11110000. ICs 5, 11, 12, 13 & 14,with their associated D I P switch,count up the number of bytes in a scan and when the preset value selected by the switch is reached, cause a continuous stream of "ones" to be telemetred.

The telemetry process is controlled by the signals from ICs 9 & 5 When the digitization process is complete a "read mem." signal is sent to this circuit which generates a parallel shift signal. This controls the data transfer into a part of the long telemetry register not serviced by the memory and multiplexer card and starts the telemetry circuit. Finally, this control circuit generates a "start digitizer" signal to restart the digitization process.

Square waves, F and 2F, are integrated using components R2, R3, R4, R5 and C2, C3, C4 and C5. Data and $\overline{\text{data}}$ control switch IC4 and cause the appropriate one of these two frequencies to be applied to a differential shaping circuit comprising Q1, R6 and R7. The logarithmic transfer function of this circuit produces an approximately sinusoidal output and components Q2, C6, C7, R8, R7 & R10 form an amplifier to drive the output transformer, T1 and hence the cable. Typically the



TTY/FSK TIMING

Fig. 3.1.12(2)

signal level at this point is 2v p-p (see wave form at Section 2.4).

A dc current is applied through the primary winding of T1 to generate a magnetic field opposing that caused by the 100mA supply current from the deck unit through the secondary to prevent the transformer from being saturated by the supply current.

SIGNAL GENERATOR

The signal generator produces a 10 kilohertz reference sine wave and a second sine wave phase shifted by precisely 90^0 relative to the reference (i.e., in quadrature to the reference).

The reference sine wave is used to excite the analog sensors while the quadrature signal is multiplied in a servo controlled loop in the comparator and used to null the small quadrature component caused by the reactance of the leads between the sensors and their interface circuits (thus presenting the digitizer circuit with a signal precisely in phase with the reference signal.)

Square waves used in the generation of the sine waves and having a precise phase relationship to them are used to operate synchronous detectors in the comparator circuit. They are also divided in binary counters to generate the frame clock which controls the operating rate of the digitizer circuitry and the frequency shift key clock which controls the telemetry rate.

The 640 kHz crystal with Q1, R1, R2, R3, C1 and C2 forms an oscillator. IC3 is a binary divider which generates an 80 kHz source for the FSK clock and a 40 kHz clock input which enables the two stages of D type flip-flop, IC4, to generate 10 kHz outputs 90^0 out of phase with one another. If the pin 1 output is designated 180° then pin 2 is at 0°, pin 13 is at +90 and pin 12 is at -90°. R6,R7, R8, R9 and Q3 form a buffer amplifier between IC4 and the series/parallel resonant

filter comprising C3, C4, C5, C6, T1, L1 and R10 producing a 10 kHz sinusoidal wave form between output pins 23 and 24.

C7 couples the in phase sine wave into the operational amplifiers in IC5 to produce the $\pm$ 90° sine waves on pins 29 and 30.

IC1 divides the 40 kHz clock by 10 to produce the 4 kHz clock for the oxygen interface, this 4 kHz clock is then further divided by the binary counter IC2 to produce the 250 Hz clock for the oxygen interface and the 31.25 Hz frame clock. Q4 inverts the frame clock in order to satisfy timing constraints in the oxygen interface.

DISPLAY

The display card provides engineering unit displays of pressure in decibars, temperature in degrees Celsius and conductivity in millimhos as measured by the underwater unit and updated 31.25 times per second. A fourth display labelled "frame sync" displays a number that is established to provide a check on the telemetry link and enable a computer connected by the serial data link to synchronize on the beginning of each data frame. This "frame sync" word alternates between 240 and 015 on adjacent frames so that the display will appear as a blur. When the display sample hold switch is put into the hold position the displays freeze, but the analog and computer outputs are not affected. When the displays are frozen the "frame sync" will read either 240 or 015 if the CTD is functioning correctly.

Each BCD character is displayed by a Hewlett Packard dot matrix light emitting diode element (HP-5082-7302) these elements have internal latches decoders and drivers. The parallel BCD data is presented to all of the columns having the same BCD weight (ten thousand, thousands, hundreds, tens, or units) in parallel and the appropriate row or variable is strobed with a pulse at the correct time for that variable every 32 ms.

This "correct time" is determined by "ANDING" four inputs.

1) Hundreds bit time

2) Tens bit time

3) Units bit time - all from demodulator "Bit time" counter.

4) Enable time - from number converter to scale the display.

For example the temperature display is strobed at bit time 054 and enable E15, one latter causing the display to be one half of the 16 bit binary number generated in the underwater unit. Variables displayed on the right side of the display board have a sign option. The signs are incorporated by latching the contents of the sign byte into ICs 15 and/or 18 and outputing them to the appropriate sign displays.

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NUMBER CONVERTER

The second card in the deck unit is the number converter, which converts a 16 bit binary number into 20 bit binary coded decimal (BCD). This technique is described by Couleur (1958). As the binary number is shifted Most Significant Bit (MSB) first into a 21 bit register the value of each BCD stage is tested and the value of any BCD stage greater than 4 is increased by 3; the new number is then serially shifted one place left and each stage retested. After 16 such shifts the conversion is conplete.

As an example Fig. 3.2.2 shows conversion of the 8 bit binary number 1000,0000.

The clock for the conversion process is generated on the number converter board using a two inverter RC oscillator IC30. A '4017' counter counts 20 pulses of this clock gated with $\overline{L}$ or S depending upon the data source. During the positive half cycle of the bit time clock K the data source for the number converter is the parallel in serial out shift register on the demodulator card. If the computer has strobed data into the shift registers on the number converter card during the previous cycle time, a flag S' will have been set and during the negative half cycle of the bit time clock the number converter data source becomes the parallel-in serial-out registers IC1 and IC8. Data steering is done with IC28 and the bit clock K. (See fig. 3.2.2(2))

The clock is counted with IC16 and the first half of IC29. Enable pulses used for scaling in powers of 2, E_6 thru E_9 and E_{14}

Fig. 3.2.2

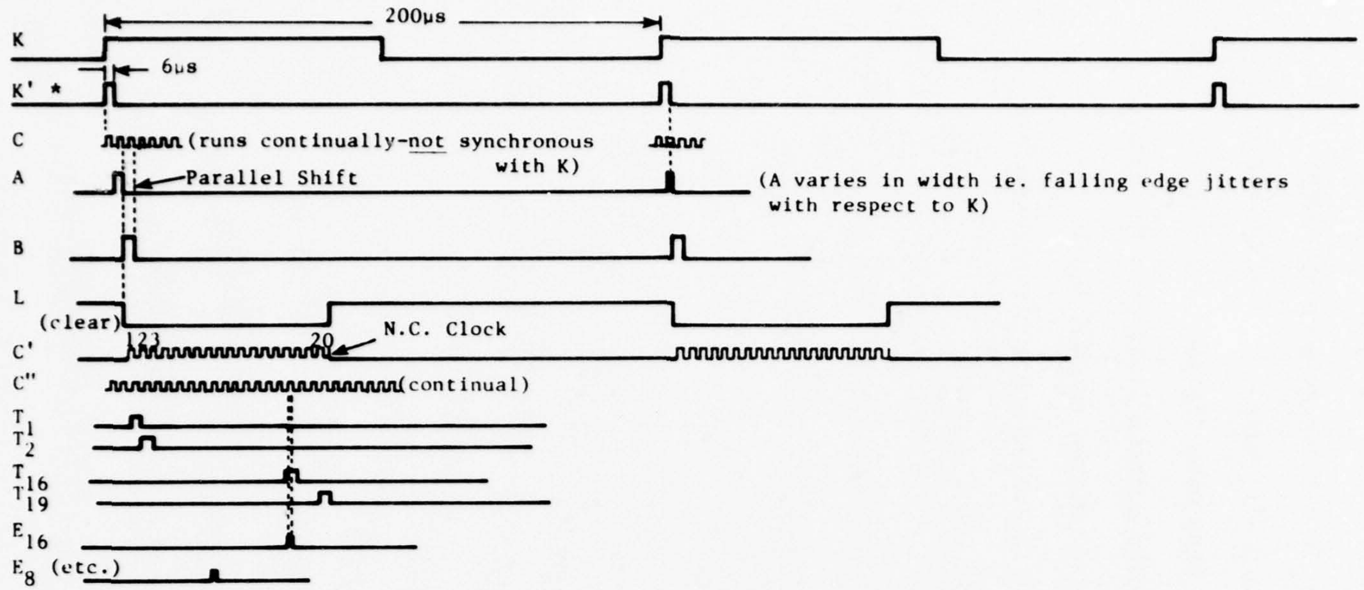
H	T	U		TEST	ACTION	BCD
			10000000			0
		1	0000000	<5	SHIFT	1
		10	000000		SHIFT	2
		100	00000	<5	SHIFT	4
		1000	0000	$U \geq 5$	ADD 3	8
		1011	0000		SHIFT	
	1	0110	000	$U \geq 5$	ADD 3	16
	1	1001	000		SHIFT	
	11	0010	00	<5	SHIFT	32
	110	0100	0	$T \geq 5$	ADD 30	64
	1001	0100	0		SHIFT	
1	0010	1000				128

BINARY TO BCD CONVERSION

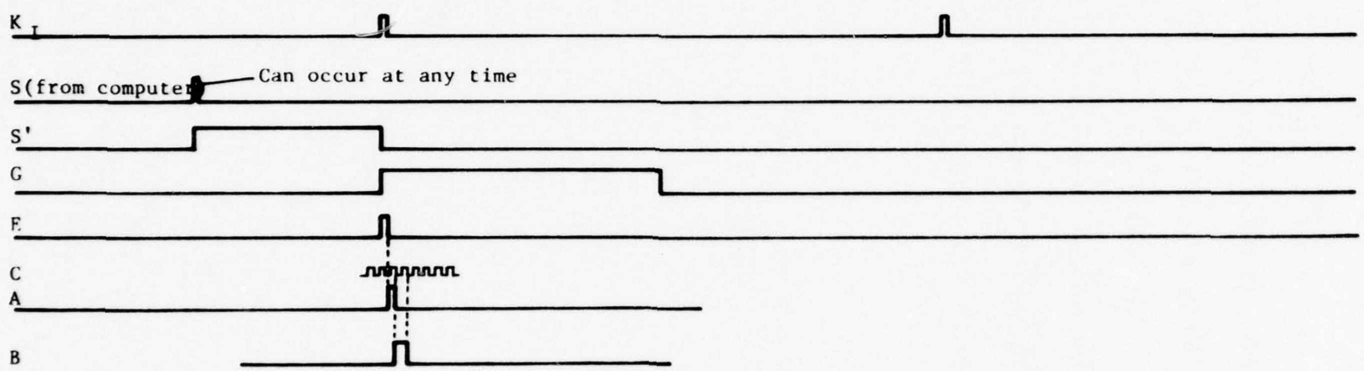
thru E_{17} are gated from the decoded counter outputs using the pulse C" and ICs 2, 9 and 23. E_{16} occurs when the 16 bit binary word has been converted. When E_{17} occurs the binary word will have been decoded and multiplied by 2, when E_{15} occurs it will have been divided by 2, etc.

This board also handles the sensor address lines from the computer; the address signals are inverted and shifted to CMOS levels to select the appropriate display or digital to analog converter channel. These levels must remain high for at least 200 μ seconds.

Fig. 3.2.2(2)



*The sequence shown above can also be iniated by input signal E which can occur 1/2 clock time ie. 100μs after K. E. occurs after a computer interrupts S (see next part II)



NUMBER CONVERTER TIMING DIAGRAM

DECK UNIT DIGITAL TO ANALOG CONVERTER

These circuits provide three 0 to 10 volts dc analog outputs proportional to temperature, pressure and conductivity, each capable of driving a channel of a recorder. For example temperature and conductivity can be plotted as a function of pressure with a 3 parameter, 2 axis recorder.

Of the four least significant BCD characters from the Number Converter three contiguous characters are selected by means of IC3, IC4 IC5 and IC9 in conjunction with the analog range select switches on the data terminal front panel. At the appropriate byte time and enable time selected by ICs 1 & 2 each variable is strobed into a different pair of hex latches, ICs 16 & 15, IC14 & 13, or IC12 & 11, if the analog Sample Hold switch is in the Sample position. The outputs of these pairs of latches are connected to digital to analog converter modules generating continuous analog outputs updated every 32 milliseconds.

As only three of five characters are converted, when a character overflows the analog output "pages" to zero volts. For example, if the temperature range switch is set at 10, a change from 9.99° to 10.00° in temperature will cause the output to go from 9.99 volts to zero volts.

DEMODULATOR

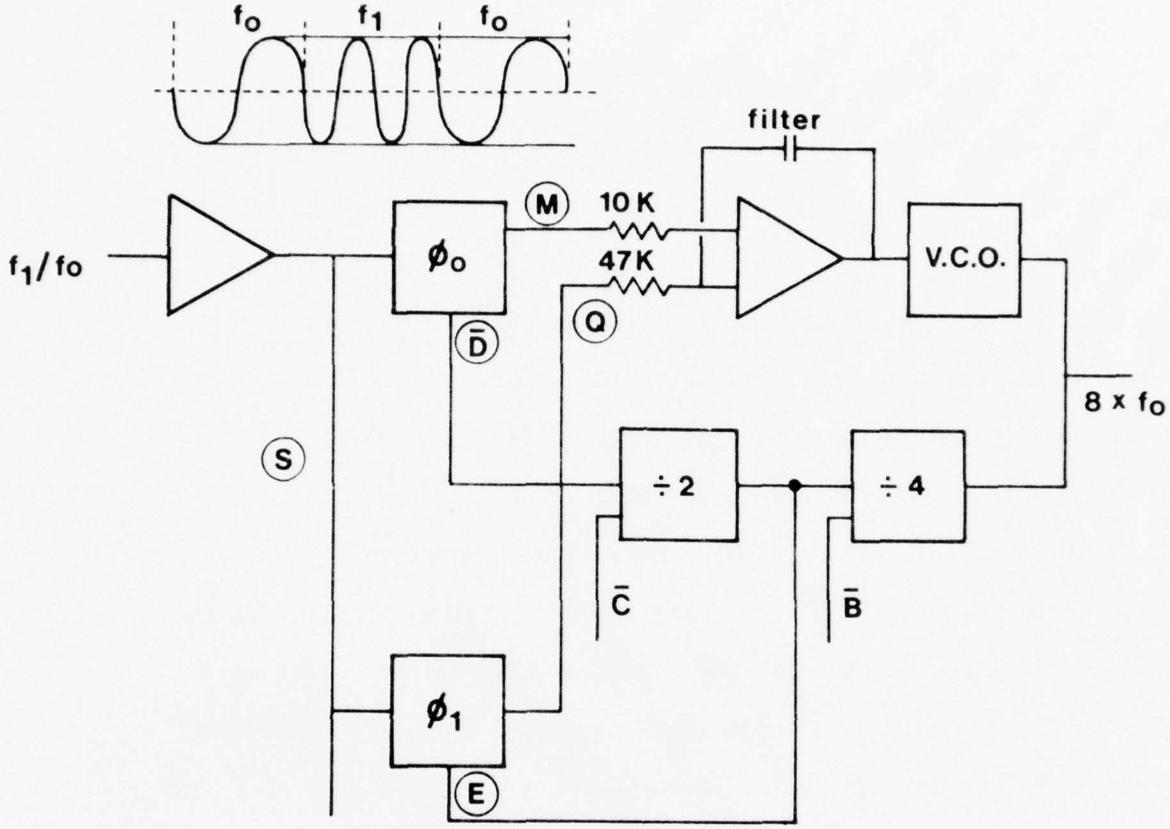
The demodulator in the deck unit is a phase locked loop with four phase sensitive detectors two of which are in the loop with their outputs added linearly. When the loop is locked the VCO runs at 40 kHz and is subsequently divided down in binary dividers to 10 and 5 kHz to provide the reference frequencies for the two phase sensitive detectors. Thus either frequency at the input will cause the loop to phase lock with the VCO running at 40 kHz with no discontinuity in the loop operation as the input frequencies jump from one to the other.

The third and fourth phase sensitive detectors are supplied with reference signals at 90^o to the reference signal as supplied to the first two detectors. These last two detectors then each synchronously detect one of the two input frequencies. When one frequency (say 5 kHz) is present the one detector output averages to a negative value while the other averages to zero. Conversely, when a 10 kHz signal is present one detector has zero average output while the other averages to a positive value. The sum of the two detector outputs is applied to the input of a limiting amplifier resulting in a logic level signal in serial TELETYPE format.

At this point the signal can be connected directly to a computer using a standard computer TELETYPE interface card modified to run at a bit rate of 5 kHz.

There is a brief discussion of phase locked loops and synchronous detectors in appendix 7.5.

Fig. 3.2.4

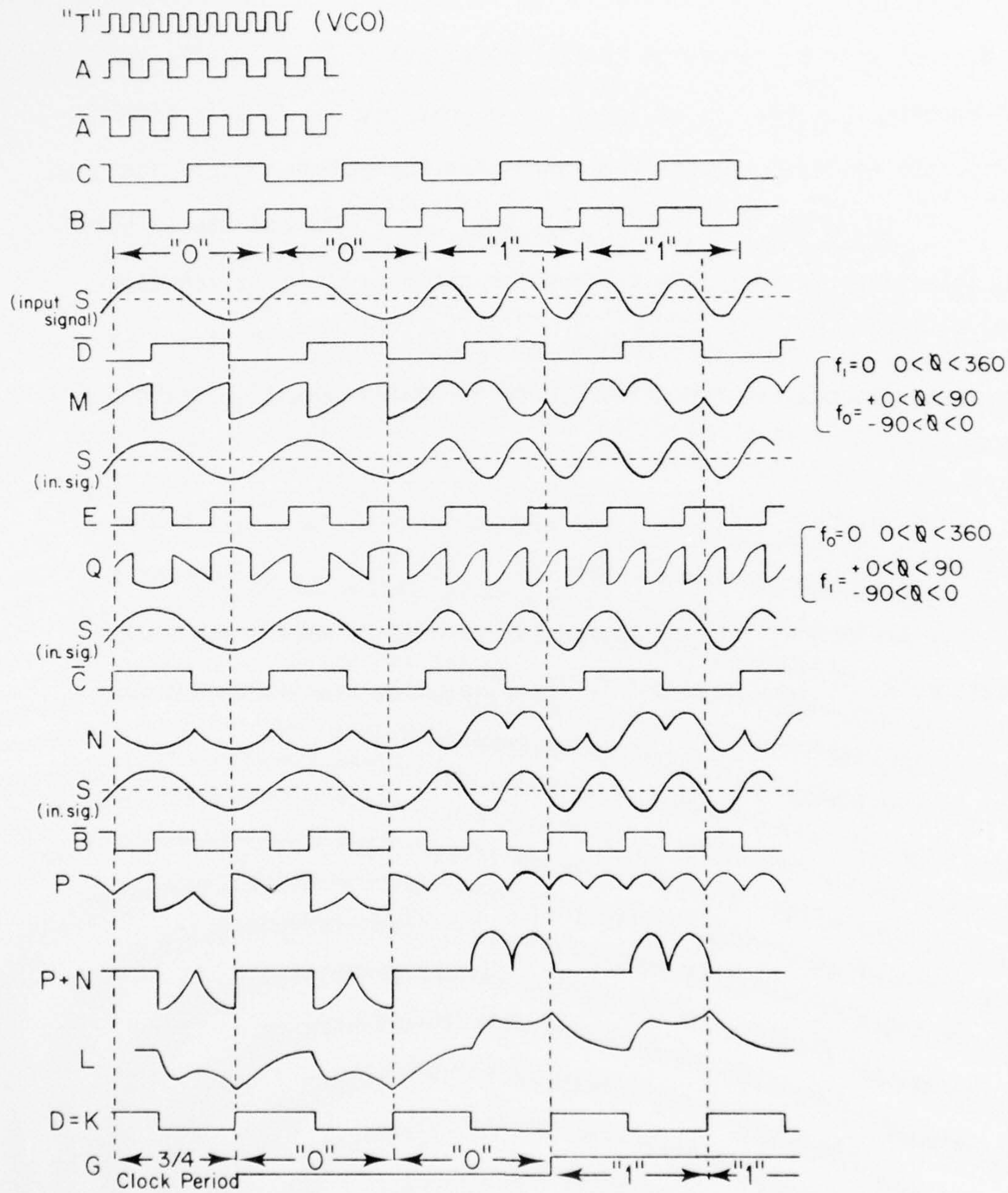


Refer to block diagram of the phase locked loop, Figure 3.2.4 and timing diagram, Figure 3.2.4(2). The first and second detectors are $\emptyset_0$ and $\emptyset_1$, detector $\emptyset_0$ generates correction signals and servos the V.C.O. while frequency f_0 (5kHz) is on line; the output from $\emptyset_1$ at this time will integrate to zero. Detector $\emptyset_1$ generates correction signals and servos the V.C.O. while frequency f_1 (10 kHz) is on line and the output from $\emptyset_0$ integrates to zero. This generates the data transmission clock. Using this clock and phase derivatives of it, the input data stream (S) will be demodulated using the third and fourth phase-sensitive detectors, $\emptyset_0'$ and $\emptyset_1'$.

Detectors $\emptyset_0'$ and $\emptyset_1'$, see Figure 3.2.4(3), are switched by the derived waveforms $\overline{C}$ and $\overline{B}$ respectively, producing the waveforms, N and P, which are summed into an integrator to produce waveforms, L and G. Waveform, G, is then detected by positive-going transitions of waveform, D, to recreate the data stream delayed by 3/4 of a clock period as shown by the timing diagram.

The data now passes through an 11 bit window on the data stream, Figure 3.2.4(4). When all 11 bits are high (logical one) the 'ANDED' output of the 11 bits goes high. In TTY format the first of a group of 11 bits is the "start" bit and will always be a zero; therefore only during the no-data time between frames is a continuous stream of ones telemetered causing this frame synchronization signal to go high. The "frame sync" pulse is used to reset the bit time counter IC13, IC14 & IC15 which counts clock transitions, K after the first start bit has caused "frame sync" to go low.

Fig. 3.2.4(2)


"T" (VCO)
A
$\bar{A}$
C
B
"0"
"0"
"1"
"1"
(input signal) S
$\bar{D}$
M
S (in. sig.)
E
Q
S (in. sig.)
$\bar{C}$
N
S (in. sig.)
$\bar{B}$
P
P+N
L
D=K
G
3/4 Clock Period
"0"
"0"
"1"
"1"
$f_1 = 0 \quad 0 < \phi < 360$
$f_0 = {}^{+}0 < \phi < 90$
$-90 < \phi < 0$
$f_0 = 0 \quad 0 < \phi < 360$
$f_1 = {}^{+}0 < \phi < 90$
$-90 < \phi < 0$

The output of the bit time counter is used with the interrupt time gates, IC1, IC2, IC3, IC4, IC5 and IC6, to control the displays and Analog outputs as well as the parallel output to a computer. A gated clock, Kg, is generated from K using IC16, IC17 and IC23 in order to shift data into registers IC9 and IC10 without the start and stop bits. Every bit time the contents of IC9 and IC10 are parallel shifted into registers IC7 and IC8 the data is then clocked by the Number Converter, from IC7 and IC8, most significant bit first, into the Number Converter. The data is always telemetred in the same sequence, so the bit time when a particular variable is in the 16 bit window in the serial data stream is unique and can be calculated using:

Interrupt Bit Time = (MS Byte # x 11) - 1.

Data Byte	Interrupted Bit Time
FRAME SYNC WORD	010
PRESSURE	032
TEMPERATURE	054
CONDUCTIVITY	076
SIGNS	087
OXYGEN CURRENT	109
OXYGEN TEMPERATURE	120

Compare figures 3.2.4, 3.2.4(3), 3.2.4(4) and schematic 5.2.4

The amplifier having output signal S is A1/1, Q1, Q2 and associated components

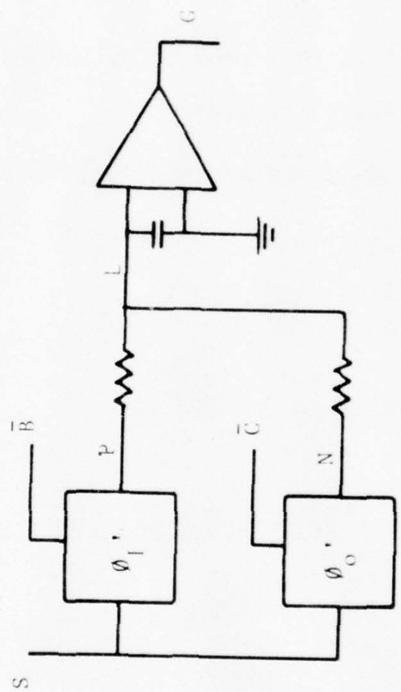
$\emptyset_0$ is A3/1 and associated components

$\emptyset_1$, is A3/13 and associated components

$\emptyset_0$, is A2/1 and associated components

$\emptyset_1$ is A2/13 and associated components

Fig. 3.2.4(3)



The integrator that generates L and finally G from P & N is A1/13 and associated components.

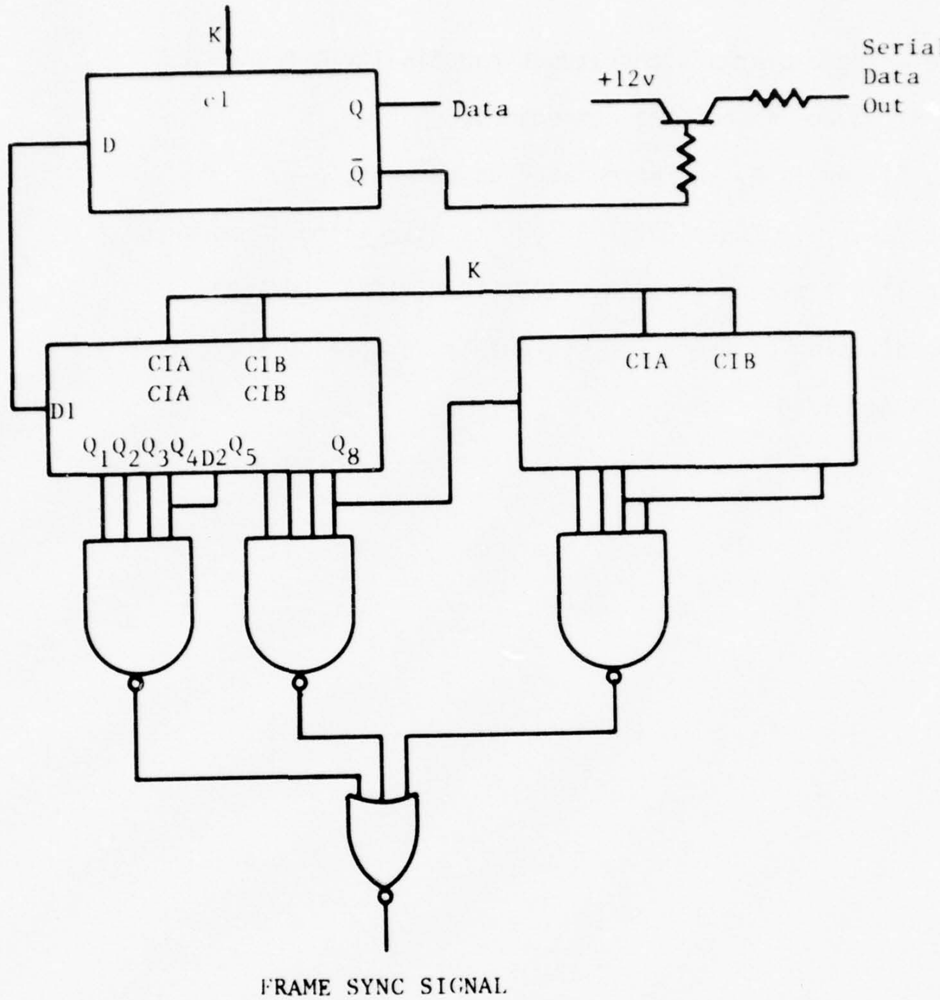
The filter is A_4 and associated components

The V.C.O. is IC37 (NE566U) and its associated components

The 11 bit window is IC18, IC19, IC20, IC21 and IC23

The division of the V.C.O. frequency is done by IC27, IC28 IC29 and IC30.

Fig. 3.2.4(4)


K
cl
Q
Data
D
Q̄
+12v
Serial
Data
Out
K
CIA
CIB
CIA
CIB
D1
$Q_1 Q_2 Q_3 Q_4$ D2 Q_5
Q_8
CIA
CIB
FRAME SYNC SIGNAL

CONSTANT CURRENT POWER SUPPLY

Refer to the circuit diagram of the constant current power supply shown on the back panel schematic, Figure 5.2.6. Constant current dc power is supplied to the Underwater Unit from a circuit driven by a 50 volt power supply. The Zener current for CR1 and base current for Q1 is provided through R2. The voltage across R1 and P1 regulates to the Zener voltage minus the base emitter voltage of Q1 thus establishing a constant current equal to

$$\frac{V_{CR1} - 0.6.}{R_1 + P_1} .$$

A reversing switch enables polarity reversal when the system is to be used in conjunction with a Rosette multi-sampler that indentifies a positive current down the cable as a signal to fire a sample bottle. For the CTD to operate in a reverse polarity mode a factory installed optional DC-DC converter is necessary, and the nominal 100 mA constant current must be increased to 160 mA. For use with long cables with a dc resistance greater than 125 ohms the 50 volt power supply needs to be replaced with a 100 volt power supply.

The choke, L1 and capacitor, C_2 are used to decouple the ac data signal from the underwater unit and the dc constant current supply to the underwater unit. The various audio transformers provide the correct impedance match between different data sources and destinations

and free users from grounding problems with audio tape recorders.

Thermistor, Th1 is in series with the 110V line to the chopper power supply to prevent power up current surges.

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FRONT AND BACK PANELS

The under side of the deck unit chassis is built with "wire wrap" interconnections to the four (optionally five) pairs of circuit card jacks and two 90 pin Elco connectors, J11 & J12. Connector, J12 is an interface between the wire wrap and soldered connection to the front and back panel controls, indicators and connectors.

Plus and minus 15 volts at 350mA and 5 volts at 6 amps are generated by a chopper power supply; a regulated 12 volts is generated on the demodulator card and all of these are buss lines on the underside of the deck unit chassis.

S1 selects the data source; either Direct from J13 or Replay from J15.

S2 & S3 reverse the phase of the two inputs to switch S1.

S4 controls the 110 volt ac input Power.

S5 is the Display S/H switch.

S6 is the analog output S/H switch.

S7, S8 & S9 control the range of the analog outputs available on connector J17 on the back panel.

S10 controls the Pressure Display range.

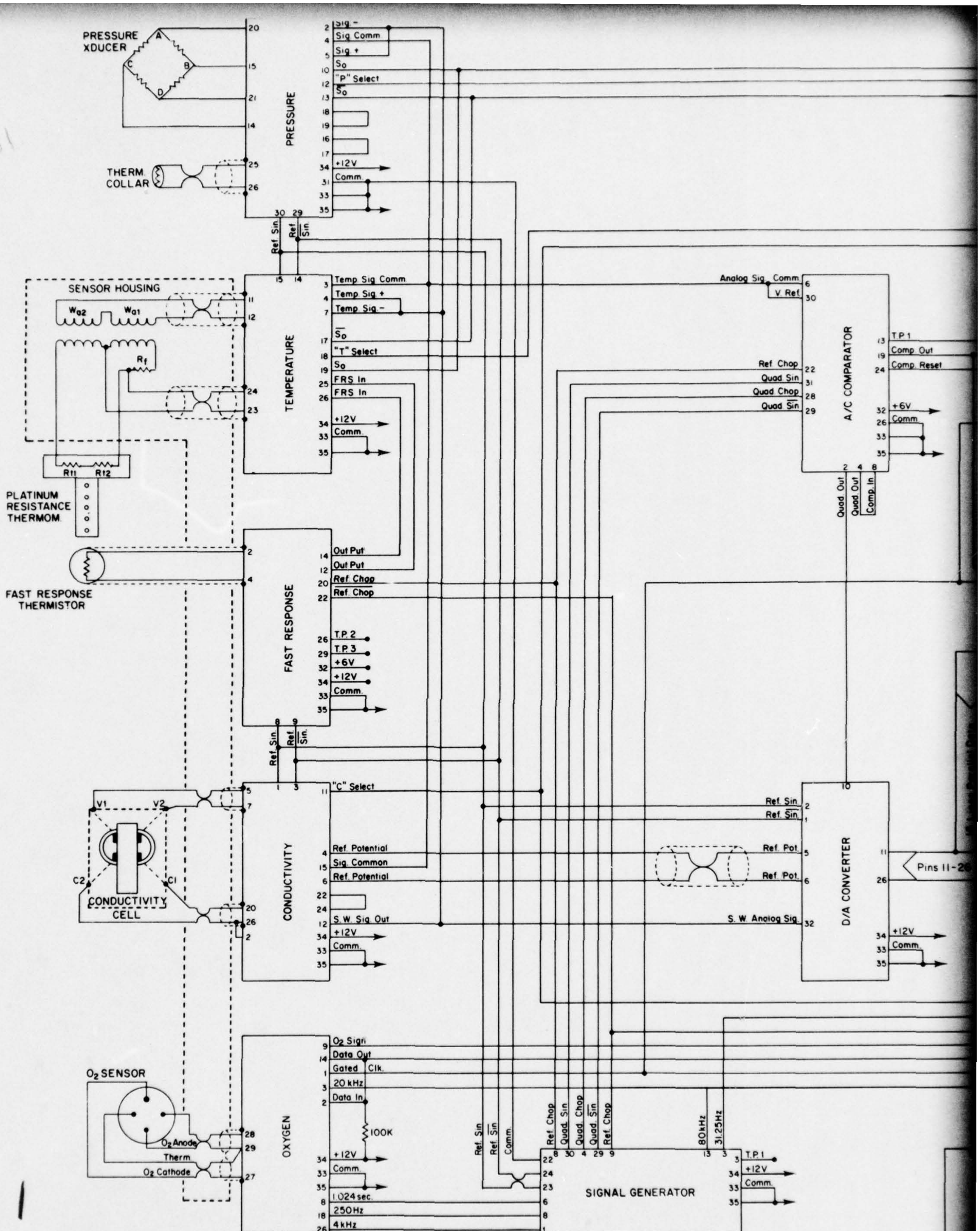
S11 controls a phase shift network intended to correct for phase shifts in the signal due to transmission up the sea cable.

P1 controls the Signal Level.

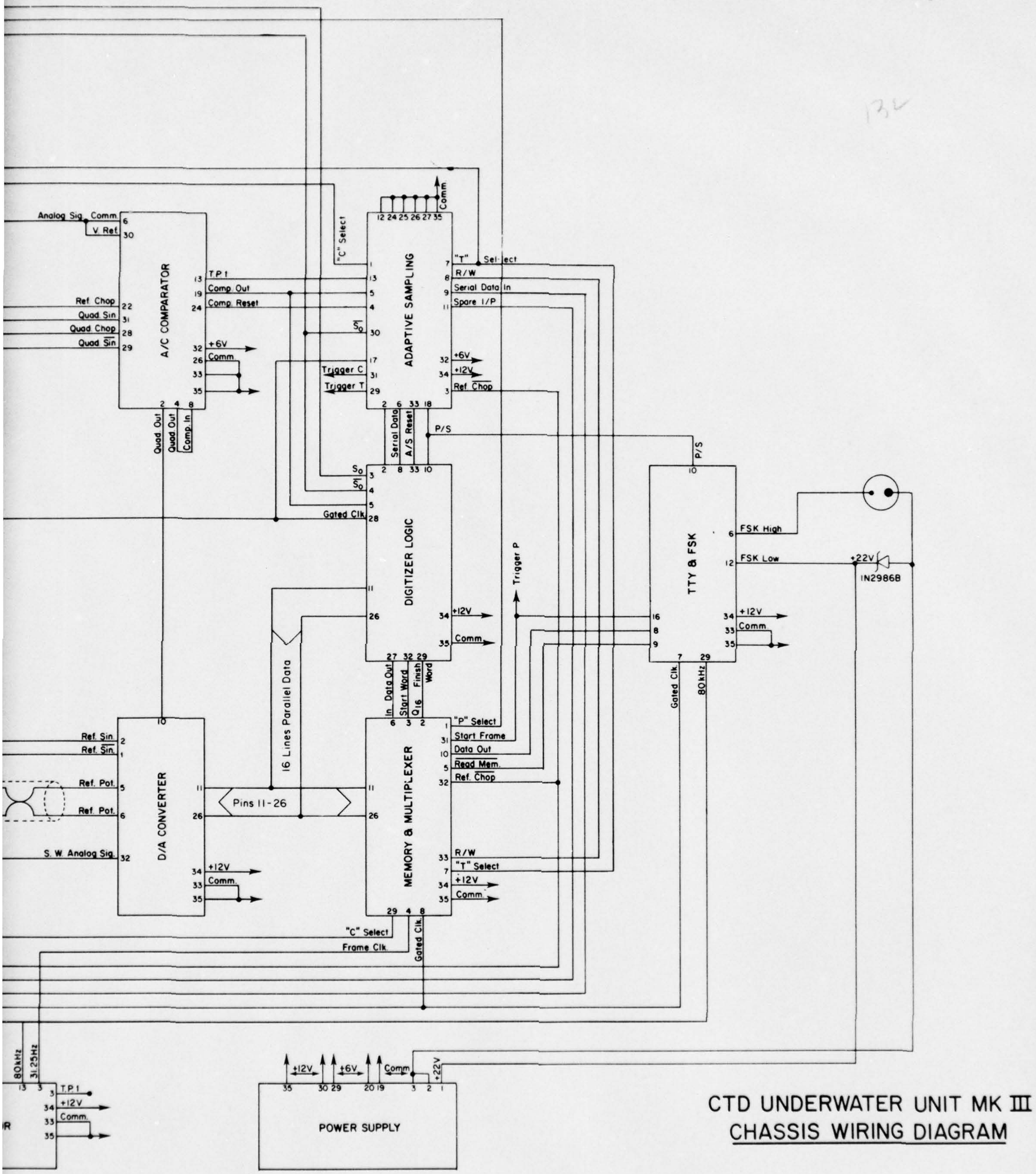
P2 controls the center frequency of the V.C.O.

P3 controls the Audio level on the speaker mounted on the front panel.

131


PRESSURE XDUCER
A
B
C
D
THERM. COLLAR
PRESSURE
Sig -
Sig Comm
Sig +
So
"P" Select
So
+12V
Comm.
Ref. Sin.
Ref. Sin.
SENSOR HOUSING
Wa2
Wa1
Rf
Rt1
Rt2
PLATINUM RESISTANCE THERMOM.
TEMPERATURE
Temp Sig Comm.
Temp Sig +
Temp Sig -
So
"T" Select
So
FRS In
FRS In
+12V
Comm.
FAST RESPONSE THERMISTOR
FAST RESPONSE
Out Put
Out Put
Ref. Chop
Ref. Chop
T.P. 2
T.P. 3
+6V
+12V
Comm.
CONDUCTIVITY CELL
V1
V2
C2
C1
CONDUCTIVITY
"C" Select
Ref. Potential
Sig. Common
Ref. Potential
S.W. Sig. Out
+12V
Comm.
O2 SENSOR
O2 Anode
Therm.
O2 Cathode
OXYGEN
O2 Sign
Data Out
Gated Clk.
20 kHz
Data In
100K
+12V
Comm.
1.024 sec.
250Hz
4 kHz
Analog Sig. Comm.
V. Ref.
A/C COMPARATOR
T.P.1
Comp. Out
Comp. Reset
Ref. Chop
Quad Sin
Quad Chop
Quad Sin
+6V
Comm.
Quad Out
Quad Out
Comp. In
D/A CONVERTER
Ref. Sin
Ref. Sin
Ref. Pot.
Ref. Pot.
S. W. Analog Sig.
Pins 11-26
+12V
Comm.
Ref. Sin
Ref. Sin
Comm.
Ref. Chop
Quad. Sin
Quad. Chop
Quad. Sin
Ref. Chop
80kHz
31.25Hz
SIGNAL GENERATOR
T.P.1
+12V
Comm.

1



CTD UNDERWATER UNIT MK III
CHASSIS WIRING DIAGRAM

UNDERWATER UNIT INTERWIRING

Each termination is given a four digit number; the first two digits designate the board number, the second two digits designate the connector pin number. Fo

Pin	J 01 PRESSURE	J 02 TEMPERATURE	J 03 FAST RESPONSE	J 04 CONDUCTIVITY	J 05 OXYGEN	J 06 POWER SUPPLY	J 07 A/C COMPARATOR	J 08 D/A CONVERTER	J DIGITI
1				0214, 0802 1323, 0309, 0219	1008, 1207 0928, 1117	End Plate P.S.		0129, 0214 1324, 0509, 040	
2	0412, 0832 0204, 0105, 0207		Sensor Hd #3	0426	0514, 1109	End Plate 0603	0830	0130, 0215 1323, 0308, 040	1102
3		0706 0415, 0104, 0730		0214, 0801 1324, 0309, 0129	1313, 1229	0602			0219, 0
4	0706, 0730 0203, 0415	0105, 0832 0412, 0102, 0207	Sensor Hd #2	0805			0708		0217, 1
5	0412, 0832 0102, 0204, 0207			Sensor Hd #22			0734	0404	0719, 1
6				0806			0730, 0415	0406	
7		0412, 0832 0204, 0102, 0105		Sensor Hd #21			0601		
8			0215 1323, 0401, 0130		1306		0704		1106
9			0129, 0214 1324, 0309, 0403		1111				
10	0219, 0903								1118, 0
11		Sensor Hd #14		1101, 1029		0535		0911, 1011	1011, 0
12	1001	Sensor Hd #15	0225	0102, 0105 0832, 0204, 0207		0735		0912, 1012	1012, 0
13	0217, 1130, 0904					0435	1113	0913, 1013	1013, 0
14	Bendix Conn. C	0309, 0403 1324, 0129	0226		1109, 0502	0835		0914, 1014	1014, 0
15	Bendix Conn. B	0308, 0401 1323, 0130, 0215		0730 0706, 0203, 0104		0335		0915, 1015	1015, 0
16	0117					0935		0916, 1016	1016, 0
17	0116	0904, 0113, 1130				0235		0917, 1017	1917, 0
18	0119	1107, 1007			1302	1335		0918, 1018	1018, 0
19	0118	0903, 0110				0135	0905, 1105	0919, 1019	1019, 0
20	Bendix Conn. A		1308, 0722	0402 Sensor Hd #17				0920, 1020	1020, 0
21	Bendix Conn. D							0921, 1021	1021, 0
22			1309, 1032, 1103	0424	100kΩ		1308, 0320	0922, 1022	1022, 0
23		Sensor Hd #4						0923, 1023	1023, 0
24		Sensor Hd #12		0422, 0402		0732	1104	0924, 1024	1024, 0
25		0312						0925, 1025	1025, 0
26		0314		Sensor Hd #18	1301	1132	0733, 0735	0926, 1026	1026, 0
27					Sensor Head #13				1006
28					Sensor Head #15		1304		1117 1008, 050
29	0309, 0403 1324, 0214, 0801				#12 Sensor Head #14	0332	1329		1002
30	0401, 0802 1323, 0215, 0308					0734, 0834	0415 0706, 0203, 0104	0702	
31	0133, 1322					0534, 0434	1330		
32			0626			0934	0627	0207, 0102, 0104 0412, 0204,	1003
33	1322, 0131, 0135	0235	0335	0435	0535	0434, 0334	0726, 0735	0835	1133
34	0634	0633	0632	0631	0631	1334	0630, 0705	0631	0632, 1
35	0619, 0133	0617, 0233	0615, 0333	0613, 0433	0611, 0533	0234, 0134	0612, 0733	0614, 0833	0616, 1

Fig. 4.2

UNDERWATER UNIT INTERWIRING

ate the board number, the second two digits designate the connector pin number. For example 0412 connects to pin 12 of circuit board 4.

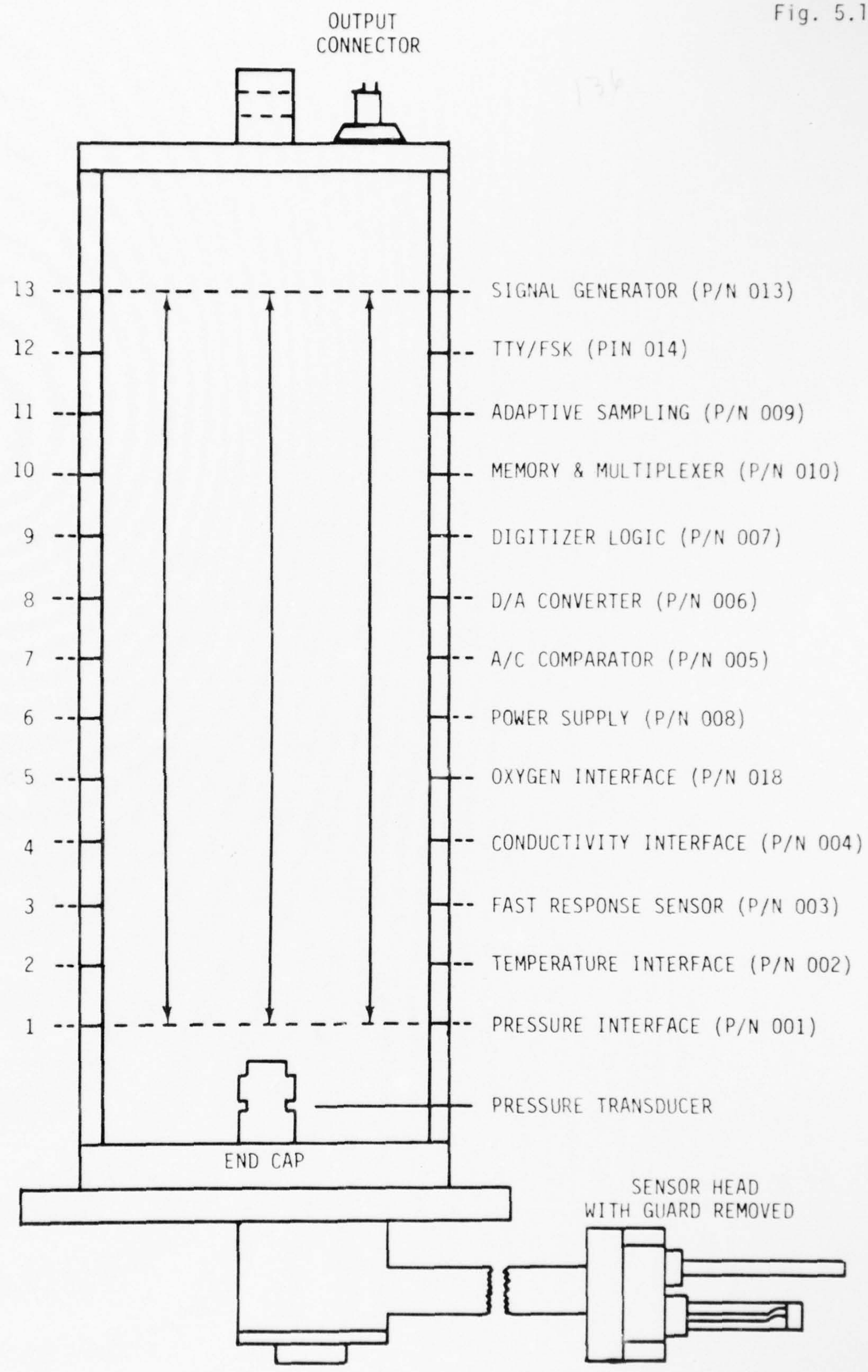
J 05 OXYGEN	J 06 POWER SUPPLY	J 07 A/C COMPARATOR	J 08 D/A CONVERTER	J 09 DIGITIZER LOGIC	J 10 MEM. & MULT.	J 11 ADAPTIVE SAMPLING	J 12 TTY/FSK	J 13 SIGNAL GENERATOR
1008, 1207 0928, 1117	End Plate P.S.		0129, 0214 1324, 0509, 040		0112	1029, 0411		0526
0514, 1109	End Plate 0603	0830	0130, 0215 1323, 0308, 0401	1102	0929	0902		0518
1313, 1229	0602			0219, 0110	0932	1032, 0322, 1309		1004
		0708		0217, 1130, 011	1303	0724		0728
		0734	0404	0719, 1105	1209	0719, 0905		
		0730, 0415	0406		0927	0908	End Cap	0508
		0601			1107, 0218	1007, 0218	1117, 1008, 0501, 0928	
1306		0704		1106	0928, 1207 0501, 1117	1033	1010	0722, 0320
1111						0514, 0502	1005	0322, 1103, 103
				1118, 0210	1208		0910, 1118	
	0535		0911, 1011	1011, 0811	0911	0509		
	0735		0912, 1012	1012, 0812	0912	1124	End Cap	
	0435	1113	0913, 1013	1013, 0813	0913	0713		1229
1109, 0502	0835		0914, 1014	1014, 0814	0914			
	0335		0915, 1015	1015, 0815	0915			
	0935		0916, 1016	1016, 0816	0916		1031	
	0235		0917, 1017	1917, 0817	0917	0501, 0928 1207, 1008		
1302	1335		0918, 1018	1018, 0818	0918	0910, 1210		
	0135	0905, 1105	0919, 1019	1019, 0819	0919			
			0920, 1020	1020, 0820	0920			
			0921, 1021	1021, 0821	0921			
100KΩ		1308, 0320	0922, 1022	1022, 0822	0922			0133, 0131, 0135
			0923, 1023	1023, 0823	0923			0215, 0130, 0802 0401, 0308
	0732	1104	0924, 1024	1024, 0824	0924	1112, 1125		0214, 0129, 0801 0403, 0309
			0925, 1025	1025, 0825	0925	1124, 1126		
1301	1132	0733, 0735	0926, 1026	1026, 0826	0926	1125, 1127		
Sensor Head #13				1006		1126, 1135		
Sensor Head #15		1304		1117 1008, 0501, 1207				
Sensor Head #12 #14	0332	1329		1002	1101, 0411		1313, 0503	0729
	0734, 0834	0415 0706, 0203, 0104	0702			0904, 0113, 0217		0731
	0534, 0434	1330			1216			
	0934	0627	0207, 0102, 0104 0412, 0204,	1003	1103, 1309, 0322	0625		
0535	0434, 0334	0726, 0735	0835	1133	1108	0933	1235	1335
0631	1334	0630, 0705	0631	0632, 1034	1134	1234	1134	0634
0611, 0533	0234, 0134	0612, 0733	0614, 0833	0616, 1035	0935	1127, 1035	1135, 1233	0618, 1333

2

135

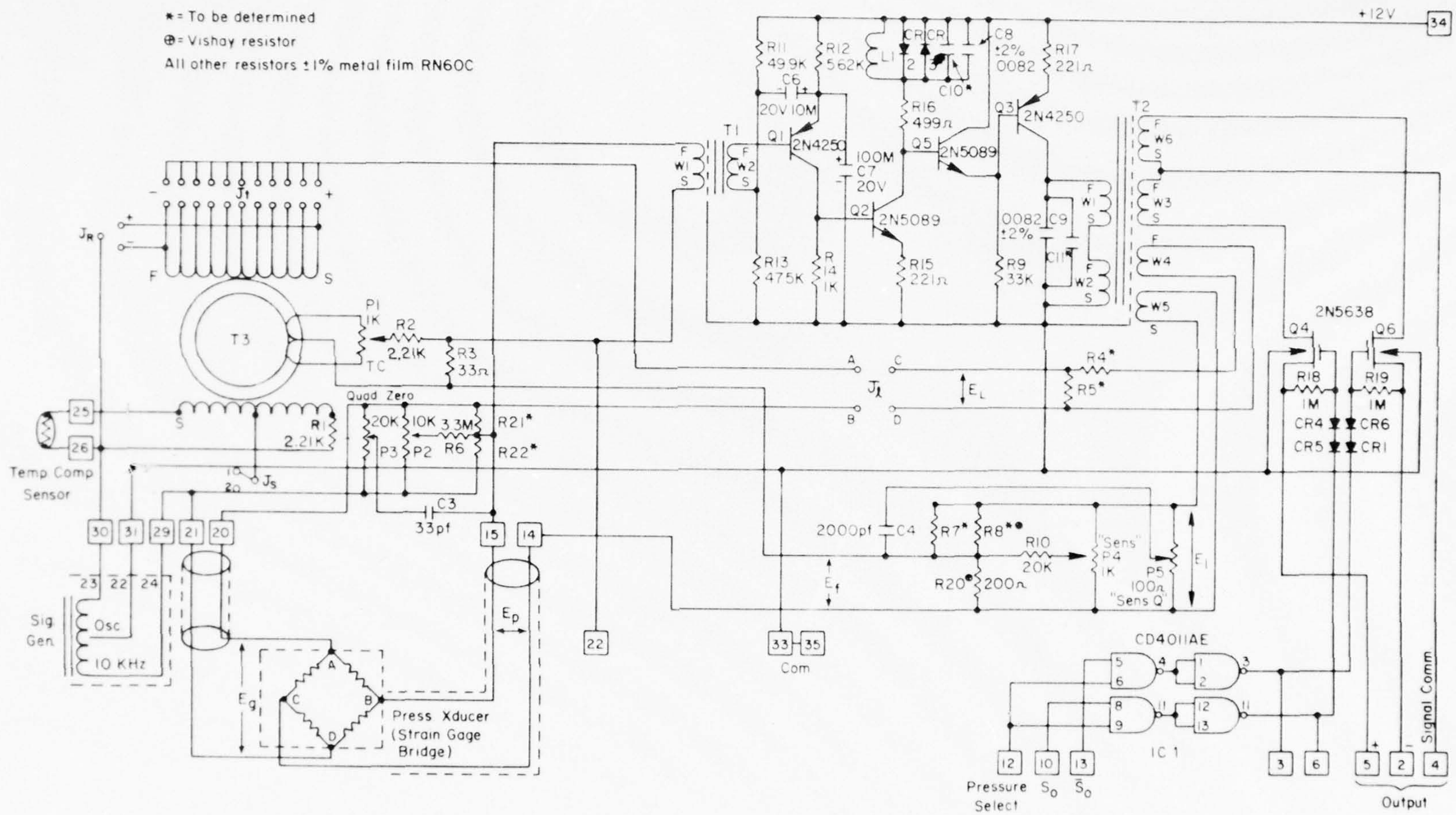
CIRCUIT BOARDS

Fig. 5.1



LOCATION OF CIRCUIT CARDS
AND WIRING HARNESSES IN UNDERWATER UNIT

Fig. 5.1.1



CTD UNDERWATER UNIT MK III PRESSURE INTERFACE

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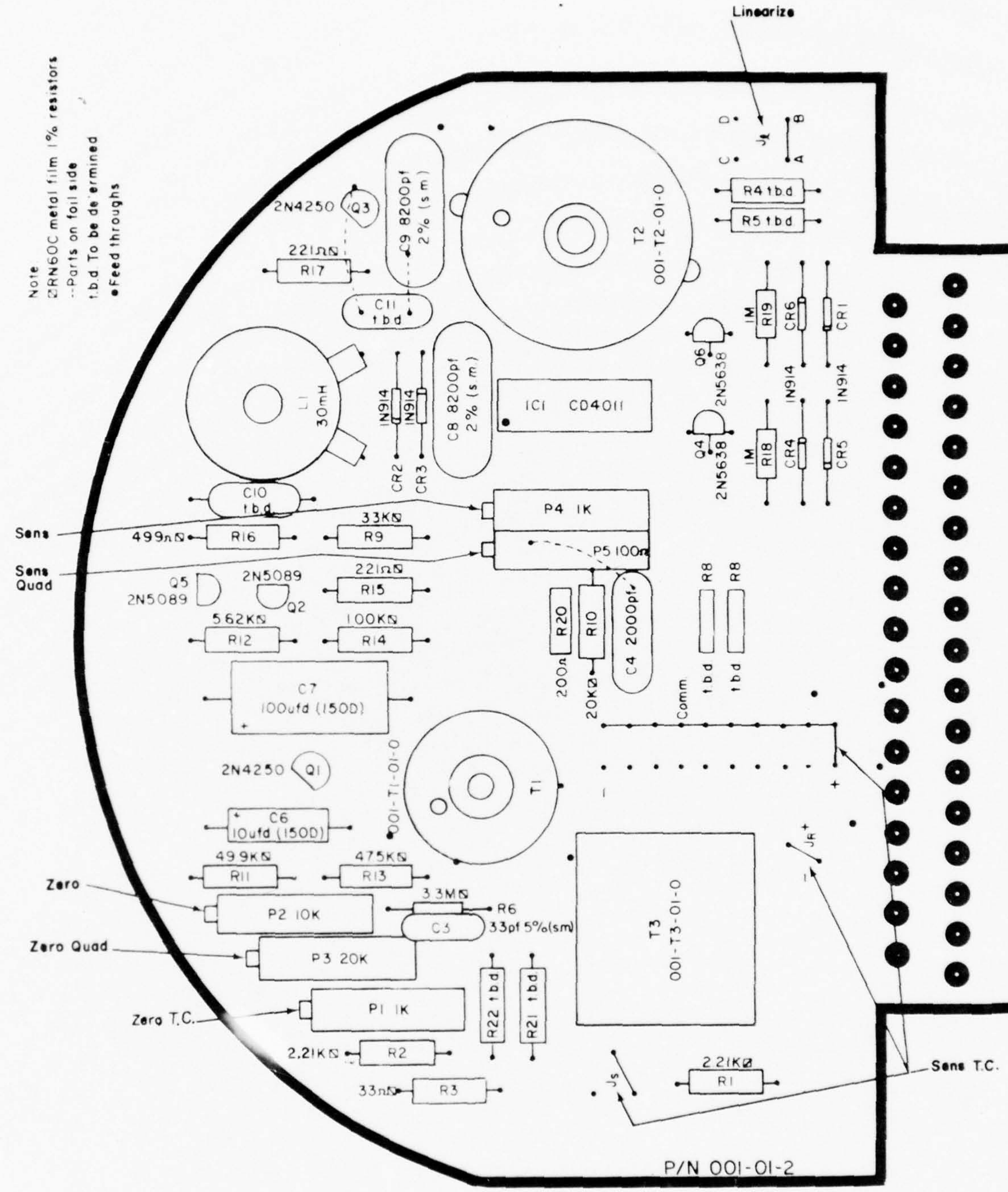
Fig. 5.1.1(2)



PRESSURE INTERFACE

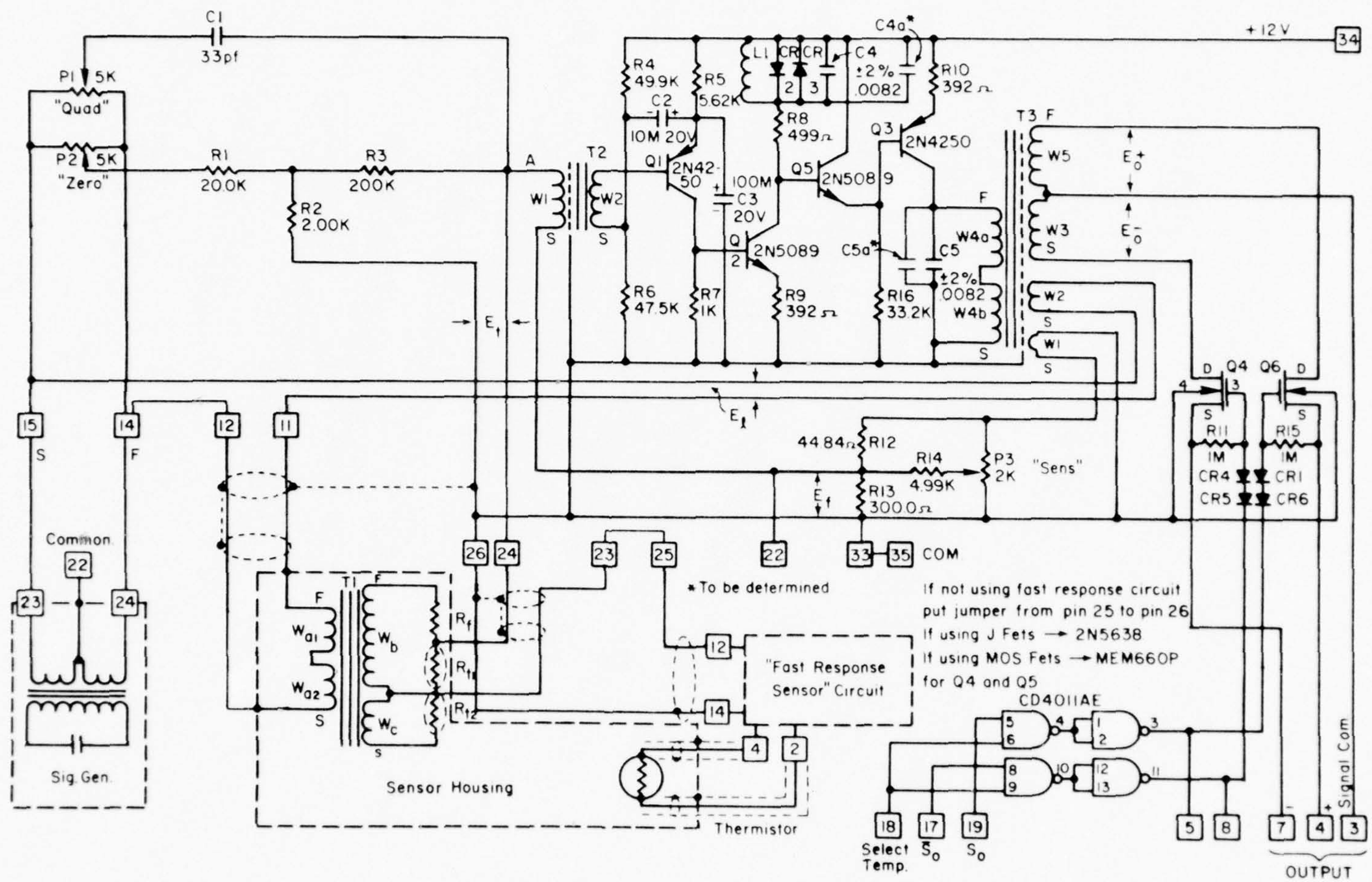
CTD Underwater Unit MK III 12/77

Fig. 5.1.1(3)

Board Title PRESSURE Board Number 01

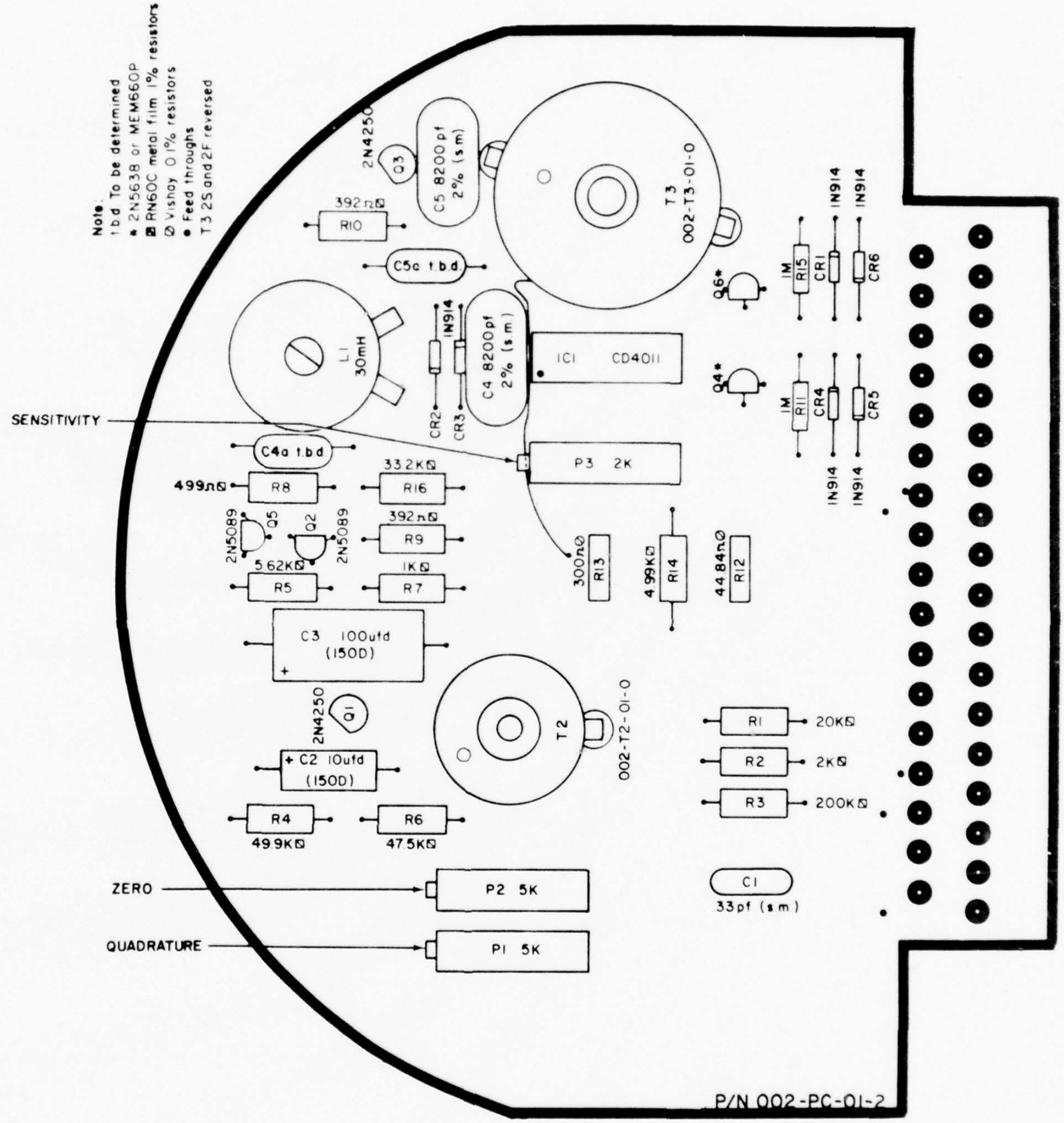
Pin	Function	Connected To	Color	Harness Postn L	Harness Postn C	Harness Postn R	Twisted With	Shielded & Twisted Pair With	Source
1									
2	SIGNAL -	0412, 0832 0204, 0105, 0207	wh			X		COAX	X
3	SELECT SIG -				X				
4	SIGNAL COMM.	0706, 0730 0203, 0415	wh			X		COAX	X
5	SIGNAL +	0412, 0832 0102, 0204, 0207	wh						
6	SELECT + SIG								
7									
8									
9									
10	So	0219, 0903	ylw		X				
11									
12	SELECT PRESS.	1001	wh/ylw		X				
13	$\overline{\text{So}}$	0217, 1130, 0904	grn		X				
14	(PRESS. TRANS)	Bendix Conn. C	blk			X		0115	
15	(DUCER O/P)	Bendix Conn. B	wh			X			
16	JUMPER	0117	wh						
17	JUMPER	0116	wh						
18	JUMPER	0119	wh						
19	JUMPER	0118	wh						
20	(TRANSDUCER)	Bendix Conn. A	blk			X		0121	
21	(EXCITATION)	Bendix Conn. D	wh			X		0120	
22	T.P.								
23									
24									
25	(TEMP. COMP.)					X			
26	(THERMISTOR)					X			
27									
28									
29	REF SINE	0309, 0403 1324, 0214, 0801	wh/blk			X	0130		
30	REF SINE	0401, 0802 1323, 0215, 0308	wh/red			X	0129		
31	TRANS. C. T.	0133, 1322							
32									
33	COMMON	1322, 0131, 0135	blk						
34	+12V	0634	red		X		0135		
35	COMMON	0619, 0133	blk		X		0134		

Fig. 5.1.2



CTD UNDERWATER UNIT MK III TEMPERATURE INTERFACE

Fig. 5.1.2(2)



TEMPERATURE INTERFACE

CTD Underwater Unit MK III 12/77

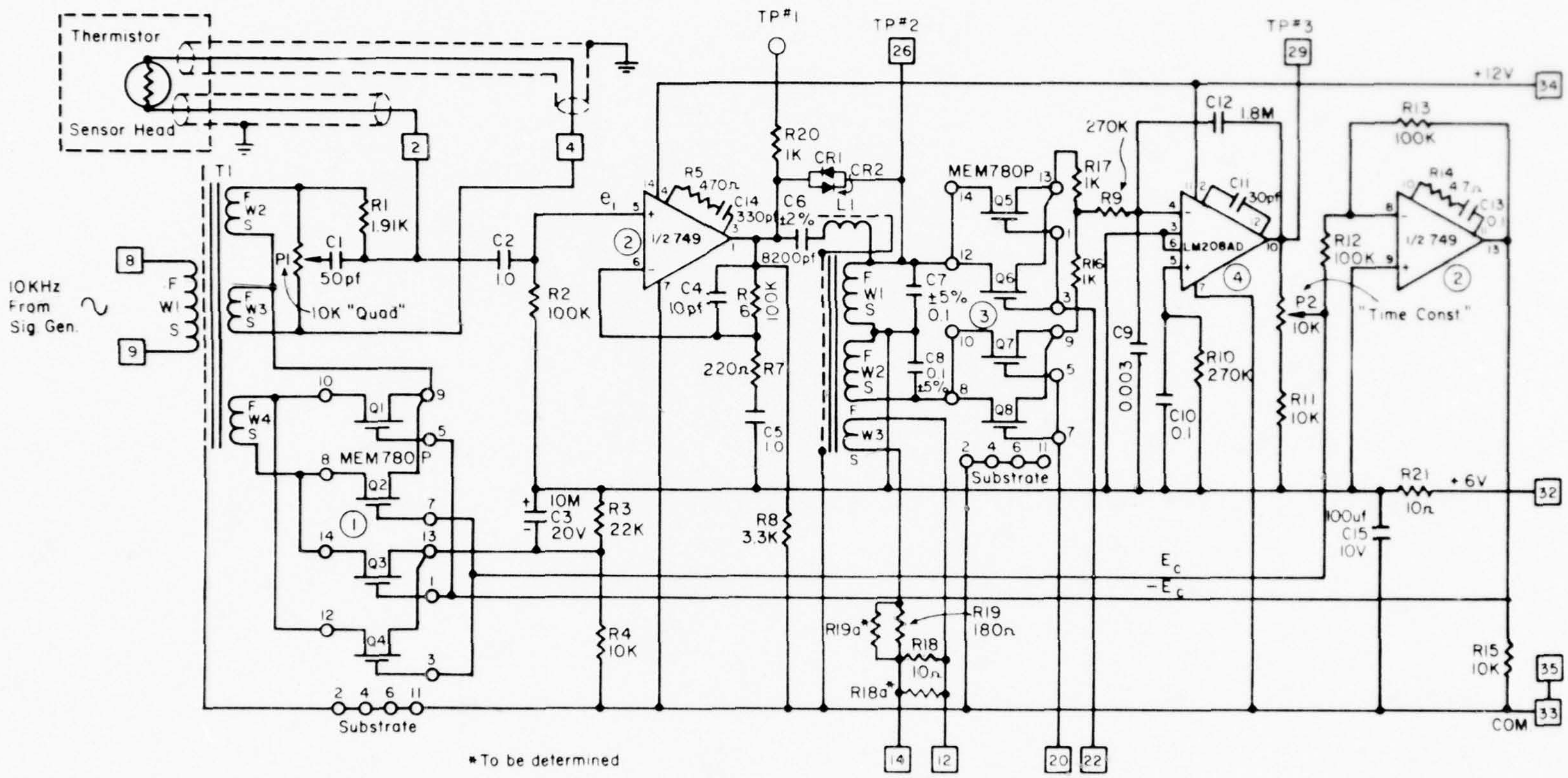
Fig. 5.1.2(3)

Board Title TEMPERATURE **Board Number** 02

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1									
2									
3	TEMP. SIGNAL COM	0706 0415, 0104, 0730	wh					COAX	X
4	TEMP. SIG. +	0105, 0832 0412, 0102, 0207	wh					COAX	X
5	SELECT + O/P								
6									
7	TEMP. SIG. -	0412, 0832 0204, 0102, 0105	wh						X
8	SELECT - O/P								
9									
10									
11	(SENS BRIDGE)	Sensor Hd #14	blk			X		0212	X
12	(DRIVE)	Sensor Hd #15	wh			X		0211	X
13									
14	REF SINE	0309, 0403 1324, 0129	wh/blk			X	0215		
15	REF SINE	0308, 0401 1323, 0130, 0215	wh/red			X	0214		
16									
17	S_Q	0904, 0113, 1130	grn						
18	SELECT TEMP	1107, 1007	wh/blk						
19	S_O	0903, 0110	ylw						
20									
21									
22									
23	(SENSOR BRIDGE)	Sensor Hd #4	blk			X		0224	
24	(OUTPUT)	Sensor Hd #12	wh			X		0223	
25	FAST. RESP. IN	0312							
26	FAST. RESP. IN	0314							
27									
28									
29									
30									
31									
32									
33	COMMON	0235							
34	+12V	0633							
35	COMMON	0617, 0233							

MKIIIb CTD

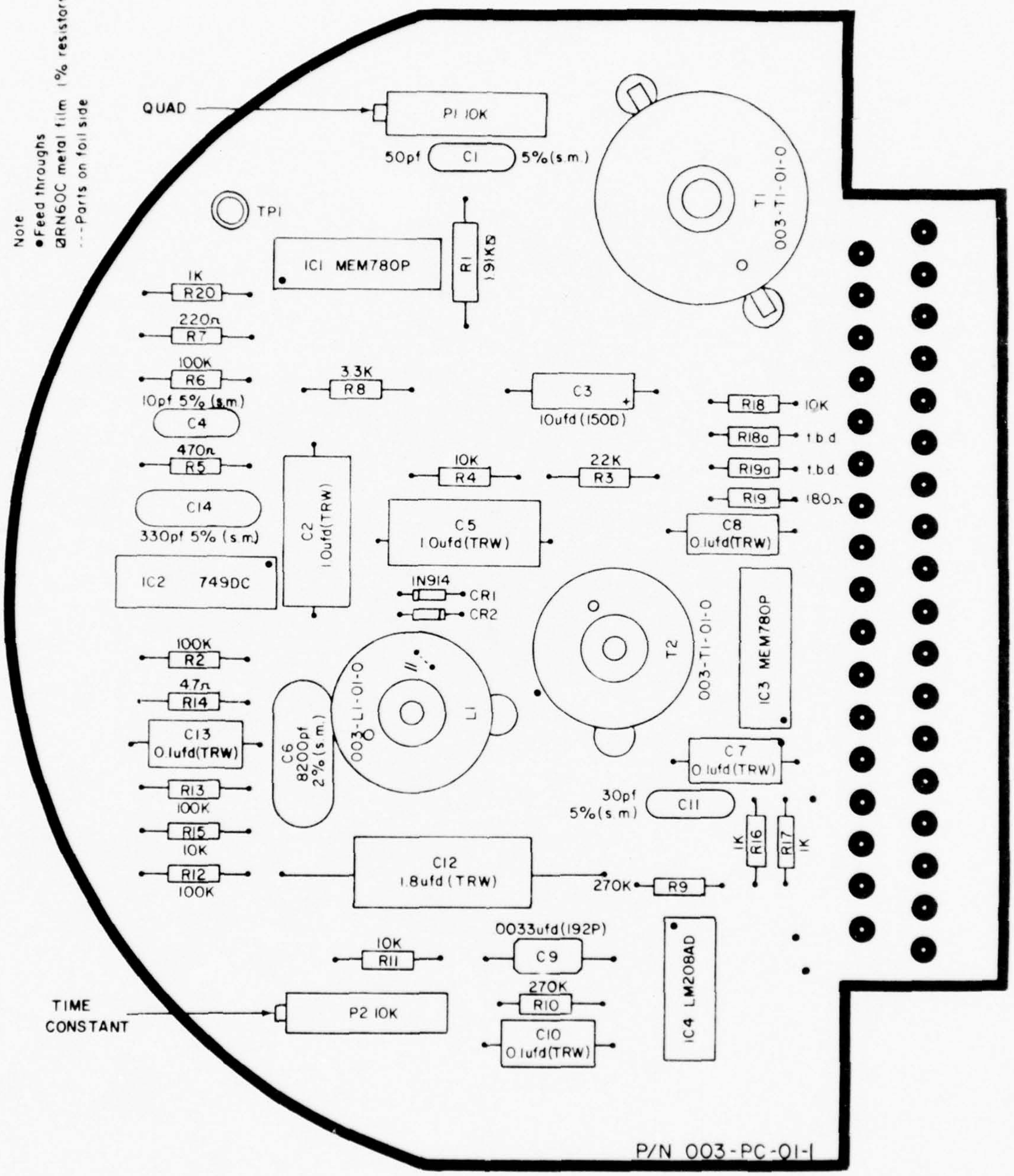
Fig. 5.1.3



CTD UNDERWATER UNIT MK III FAST RESPONSE TEMPERATURE INTERFACE

Fig. 5.1.3(2)

Note
• Feed throughs
⊠ RN60C metal film 1% resistors
--- Parts on foil side



FAST RESPONSE TEMPERATURE INTERFACE

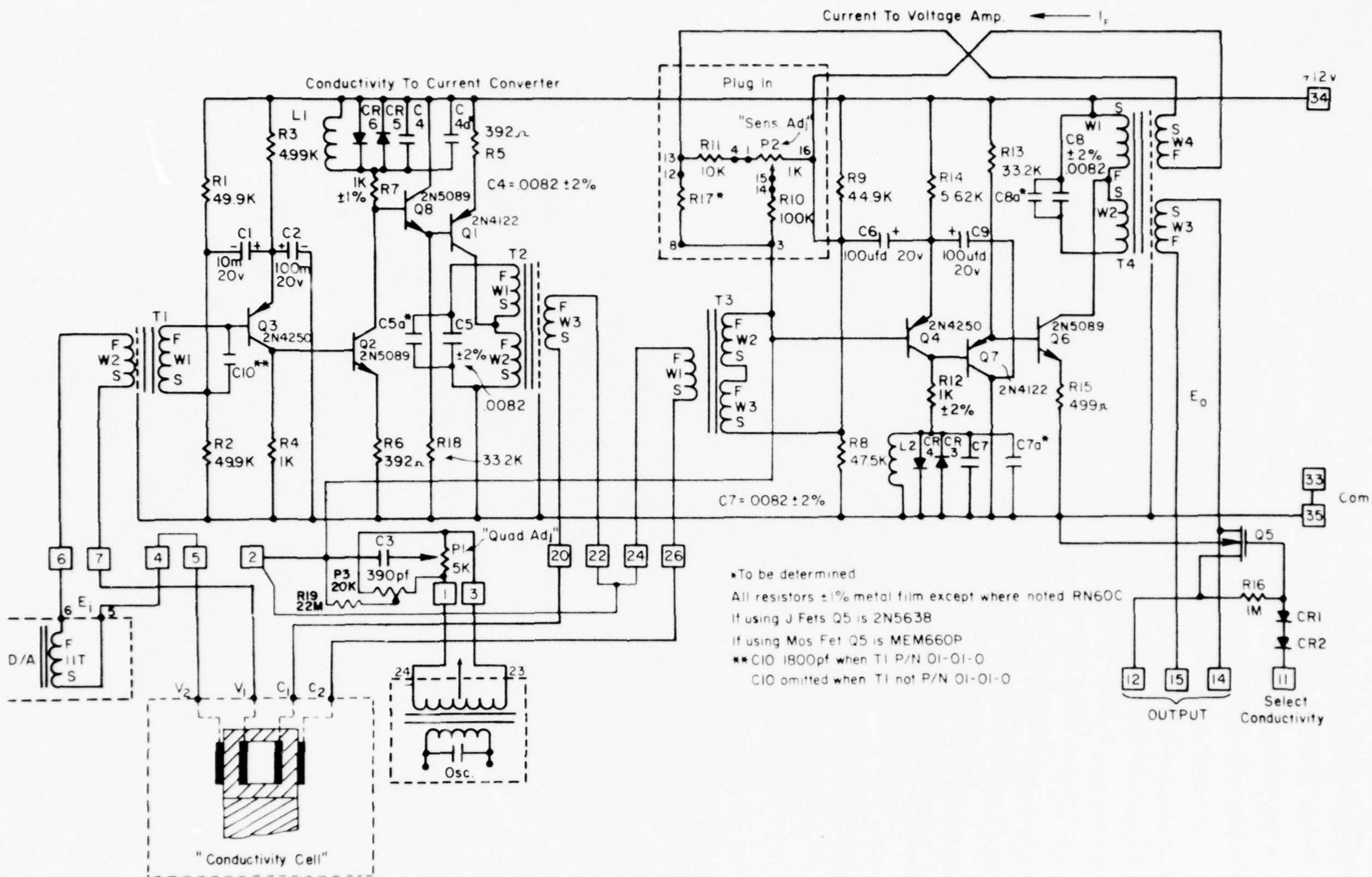
CTD Underwater Unit MK III

Fig. 5.1.3(3)

Board Title FAST RESPONSE Board Number 03

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1									
2	THERMISTOR HI	Sensor Hd #3	wh						
3									
4	THERMISTOR LO	Sensor Hd #2	wh						
5									
6									
7									
8	REF SINE	0215 1323, 0401, 0130	wh/red			X	0309		
9	REF $\overline{\text{SINE}}$	0129, 0214 1324, 0309, 0403	wh/blk			X	0308		
10									
11									
12	OUTPUT	0225	blu				0314		X
13									
14	OUTPUT	0226	blk				0312		X
15									
16									
17									
18									
19									
20	REF CHOP	1308, 0722	blu		X		0322		
21									
22	REF $\overline{\text{CHOP}}$	1309, 1032, 1103	gra		X		0320		
23									
24									
25									
26	T. P. #2								
27									
28									
29	T. P. #3								
30									
31									
32	+6V	0626	orn	X			0334, 0335		
33	COMMON	0335	link						
34	+12V	0632	red	X			0332, 0335		
35	COMMON	0615, 0333	blk	X			0332, 0334		

Fig. 5.1.4



*To be determined

All resistors ±1% metal film except where noted RN60C

If using J Fets Q5 is 2N5638

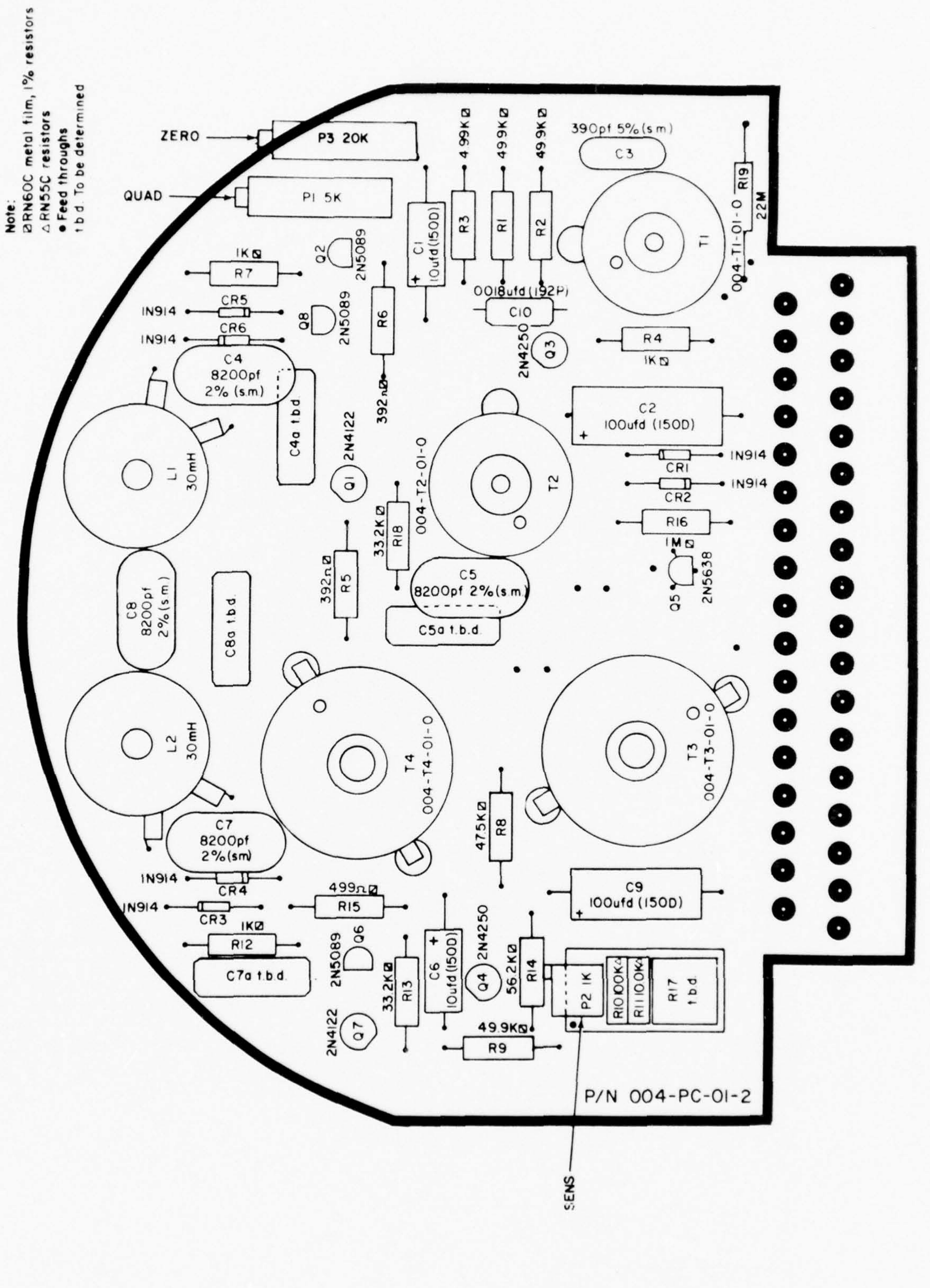
If using Mos Fet Q5 is MEM660P

**C10 1800pf when T1 P/N 01-01-0

C10 omitted when T1 not P/N 01-01-0

CTD UNDERWATER UNIT MK III CONDUCTIVITY INTERFACE

Fig. 5.1.4(2)



CONDUCTIVITY INTERFACE

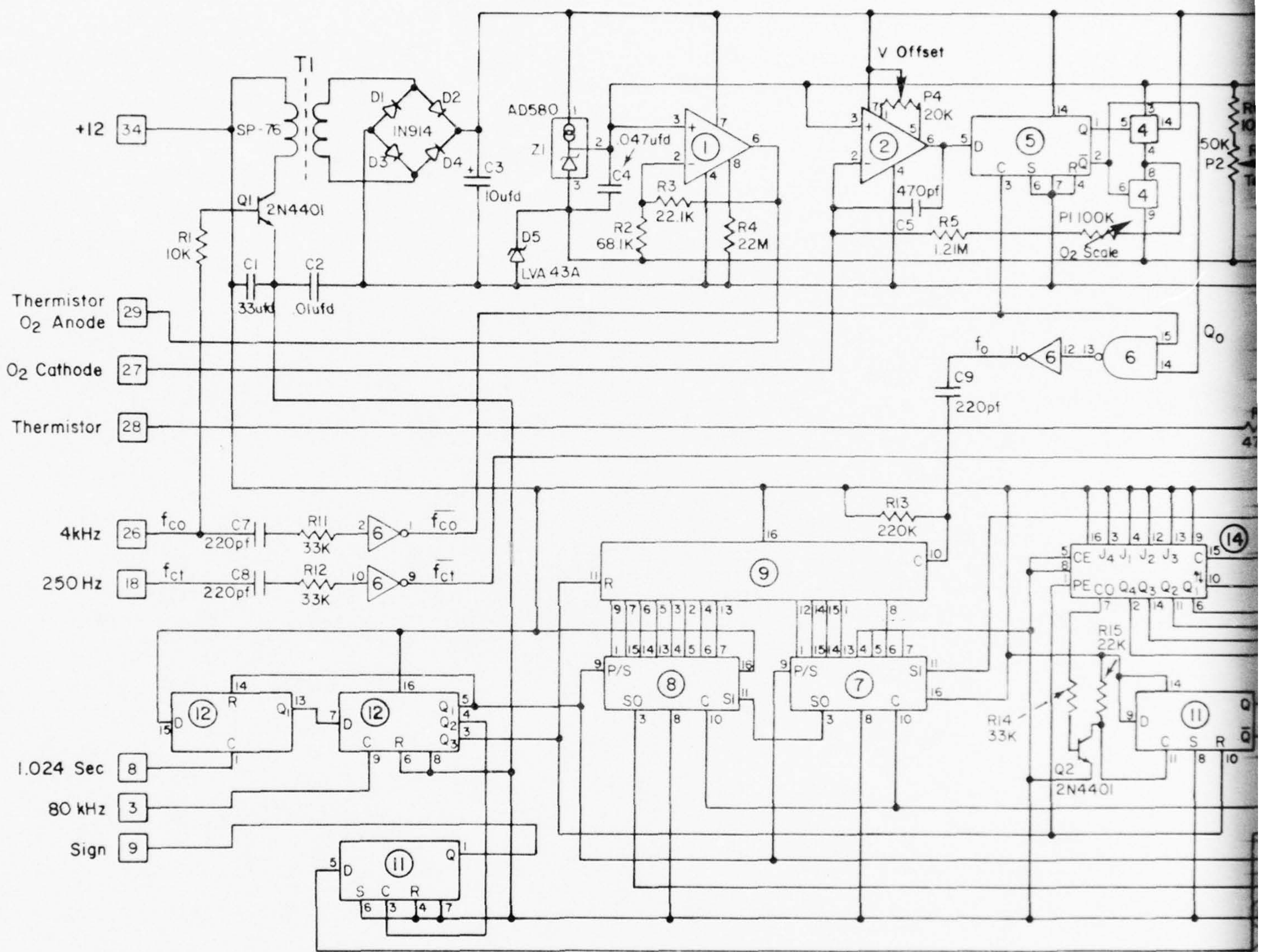
CTD Underwater Unit MK III 12/77

Fig. 5.1.4(3)

Board Title CONDUCTIVITY (3CM CELL) Board Number 04

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	REF SINE	0214, 0802 1323, 0309, 0219	wh/red			X	0403		
2	QUAD OUT	0423	orn						X
3	REF SINE	0214, 0801 1324, 0309, 0129	wh/blk			X	0401		
4	D/A REF	0805	ylw			X	0406		
5	V2 ELECTRODE	Sensor Hd #22	blk					0407	
6	D/A REF	0806	grn			X	0404		
7	V1 ELECTRODE	Sensor Hd #21	wh					0405	
8									
9									
10									
11	COND. SELECT	1101, 1029	wh		X				
12	S. W. SIGNAL OUT	0102, 0105 0832, 0204, 0207	wh			X		COAX	X
13									
14	SIGNAL OUT					X		COAX	X
15	SIG. COMMON	0730 0706, 0203, 0104	wh			X		COAX	X
16									
17									
18									
19									
20	C2. ELECTRODE	0402 Sensor Hd #17	red					0420	
21									
22	CURRENT LOOP	0424	wh						
23	QUAD IN	0402							
24	CURRENT LOOP	0422	wh						
25									
26	C1. ELECTRODE	Sensor Hd #18	blk					0426	
27									
28									
29									
30									
31									
32									
33	COMMON	0435							
34	+12V	0631	red	X			0435		
35	COMMON	0613, 0433	blk	X			0434		

MKII



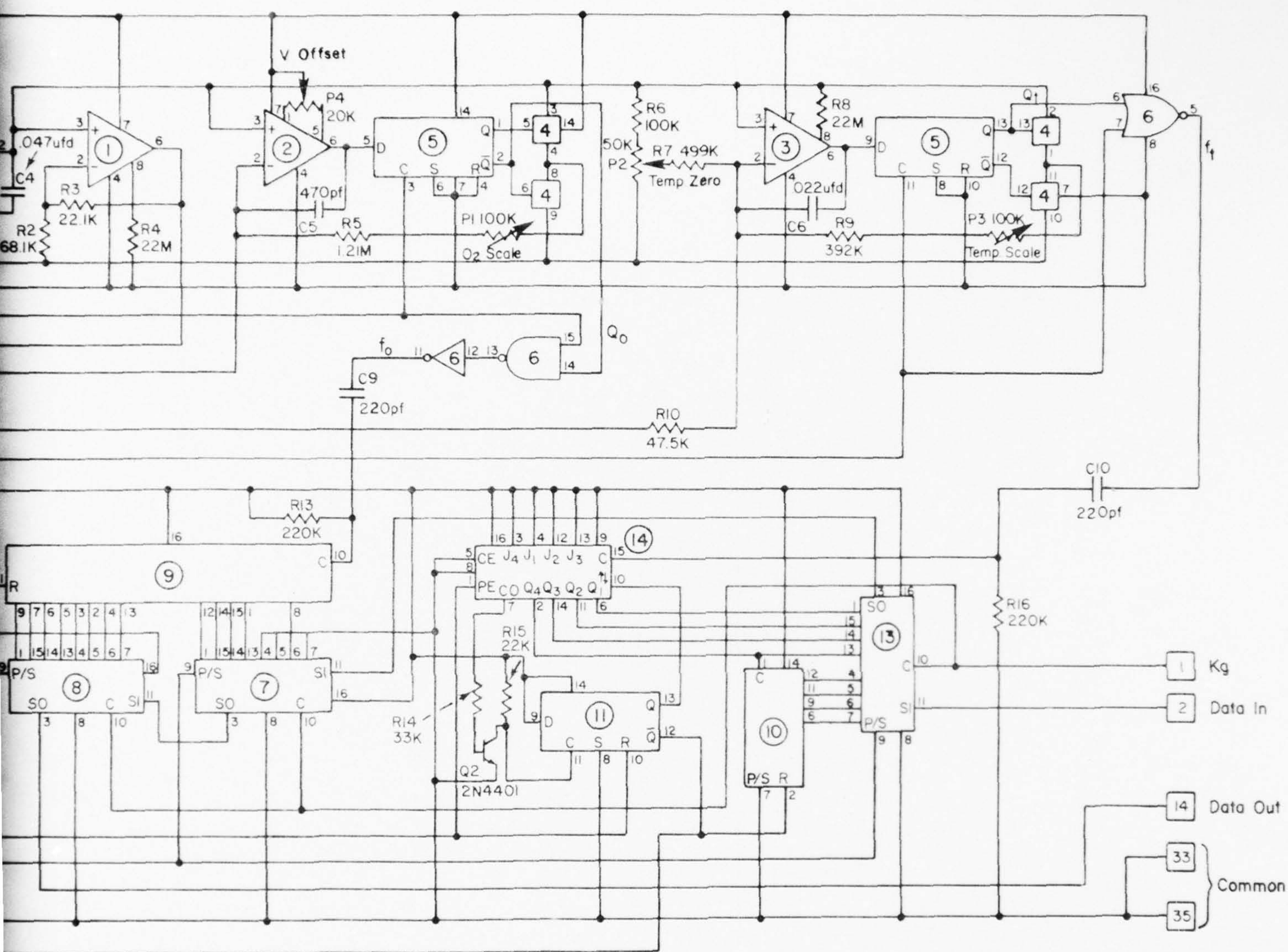
④ = CD4066AE ⑩ = CD4024AE ⑤ ⑪ = CD4013AE ② = LF355H

⑥ = MC14572CP ⑫ = CD4015AE ① ③ = μA776

⑨ = CD4040AE ⑭ = CD4029AE ⑦ ⑧ ⑬ = CD4021AE

CTD UNDERWATER UNIT MK III OXYGEN INTERFACE (

Fig. 5.1.5



= CD4013AE

(2) = LF355H

= µA776

(13) = CD4021AE

UNDERWATER UNIT MK III <u>OXYGEN INTERFACE (12 BIT)</u>

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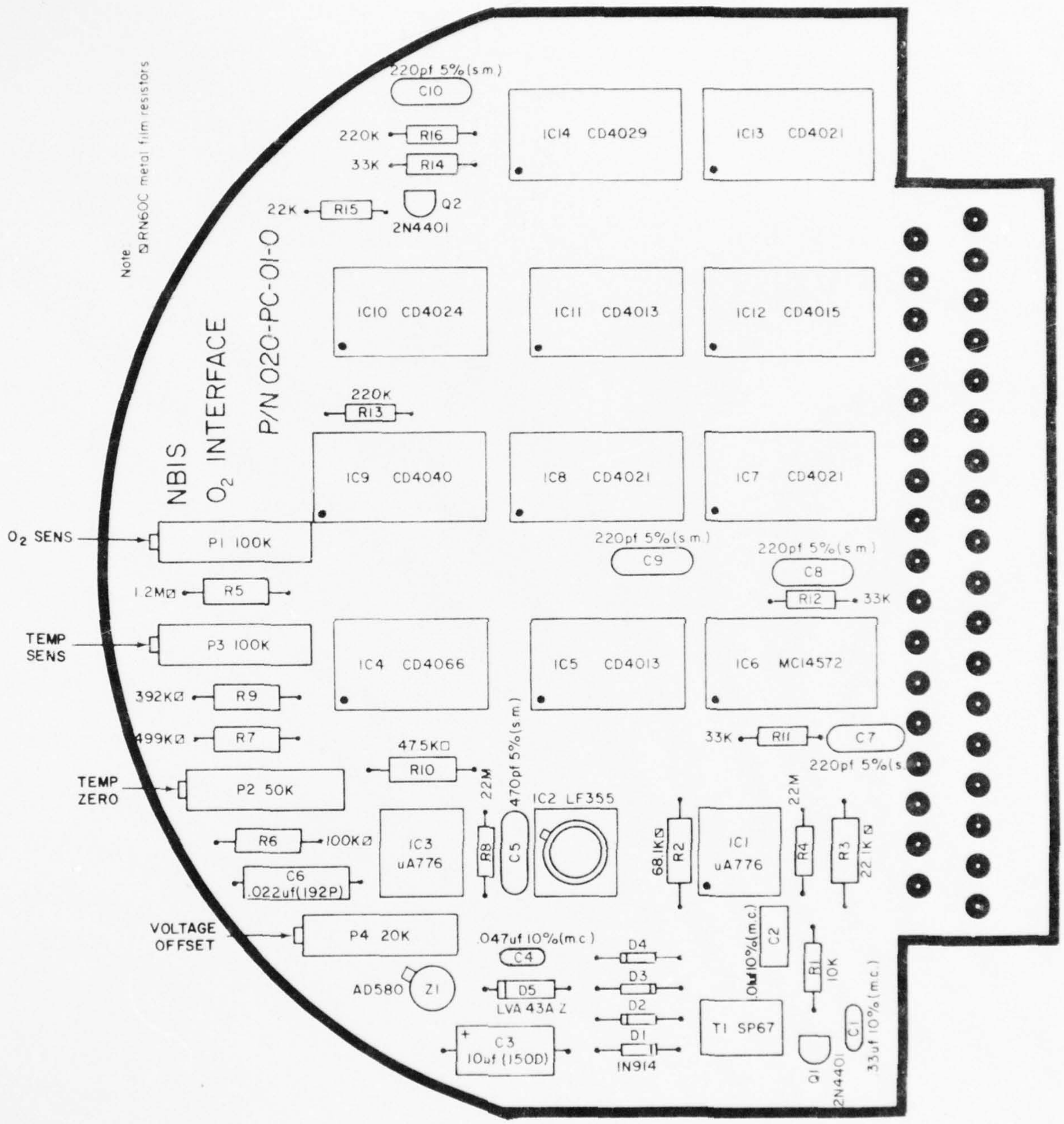
2



OXYGEN INTERFACE (12 BIT)

CTD Underwater Unit MK III

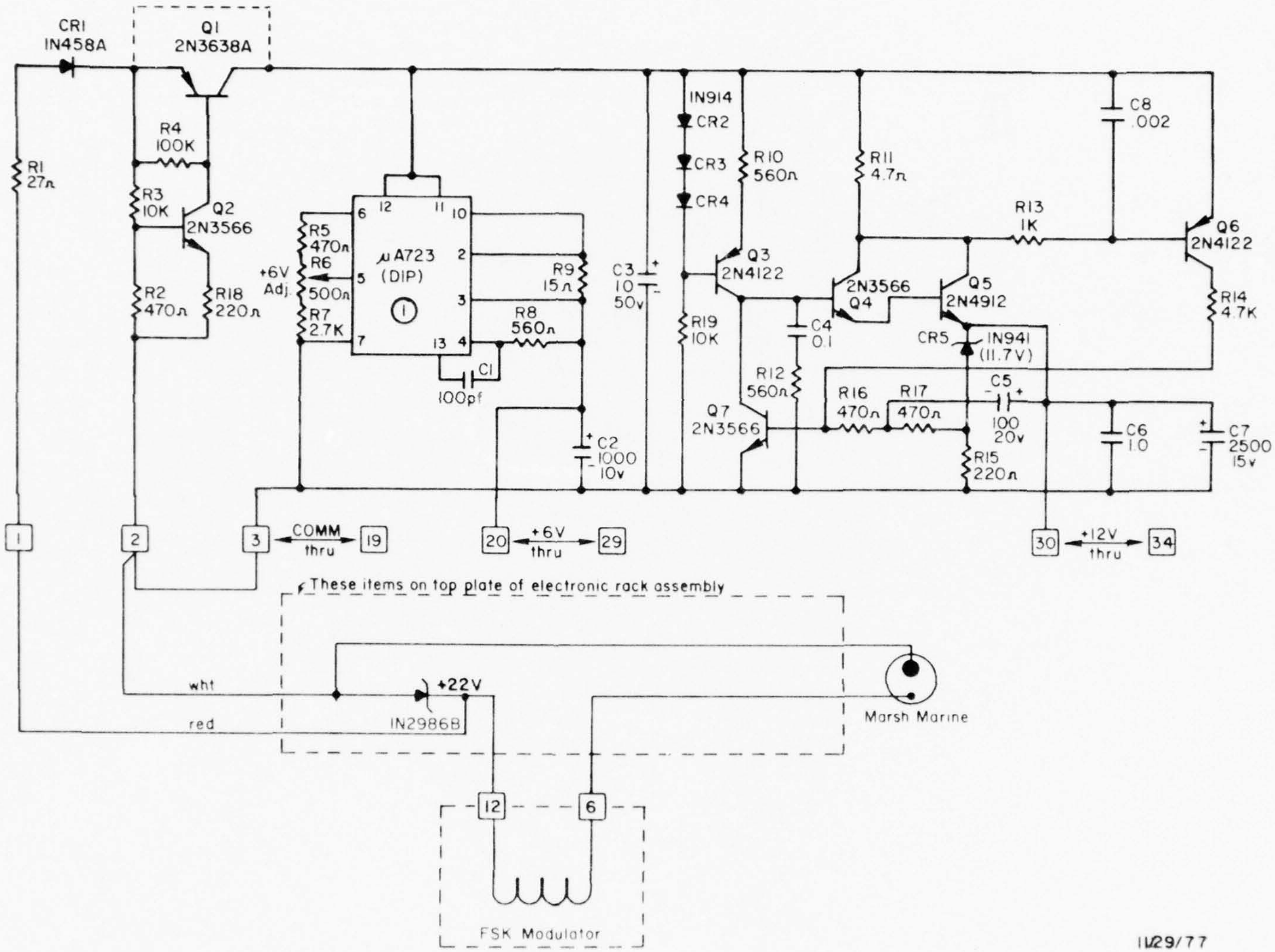
Fig. 5.1.5(3)

Board Title 12-BIT OXYGEN Board Number 05

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	GATED CLK	1008, 1207 0928, 1117	wh/blu		X				
2	DATA IN	0514, 1109	ywl		X				
3	80 KHz	1313, 1229	brn		X				
4									
5									
6									
7									
8	1.024 SEC	1306	vio		X				
9	O_2 SIGN	1111	gra		X				X
10									
11									
12									
13									
14	DATA OUT	1109, 0502	ylw		X				X
15									
16									
17									
18	250 Hz	1302	grn/wh		X				
19									
20									
21									
22		100kΩ							
23									
24									
25									
26	4 KHz	1301	orn/wh		X				
27	O_2 CATHODE	Sensor Head #13	red			X			
28	THERMISTOR	Sensor Head #15	red			X			
29	O_2 ANODE THERMISTOR	Sensor Head #12 #14	blk/blk			X			
30									
31									
32									
33	COMMON	0535		X					
34	+12V	0631		X					
35	COMMON	0611, 0533		X					

MKIIIb CTD

Fig. 5.1.6



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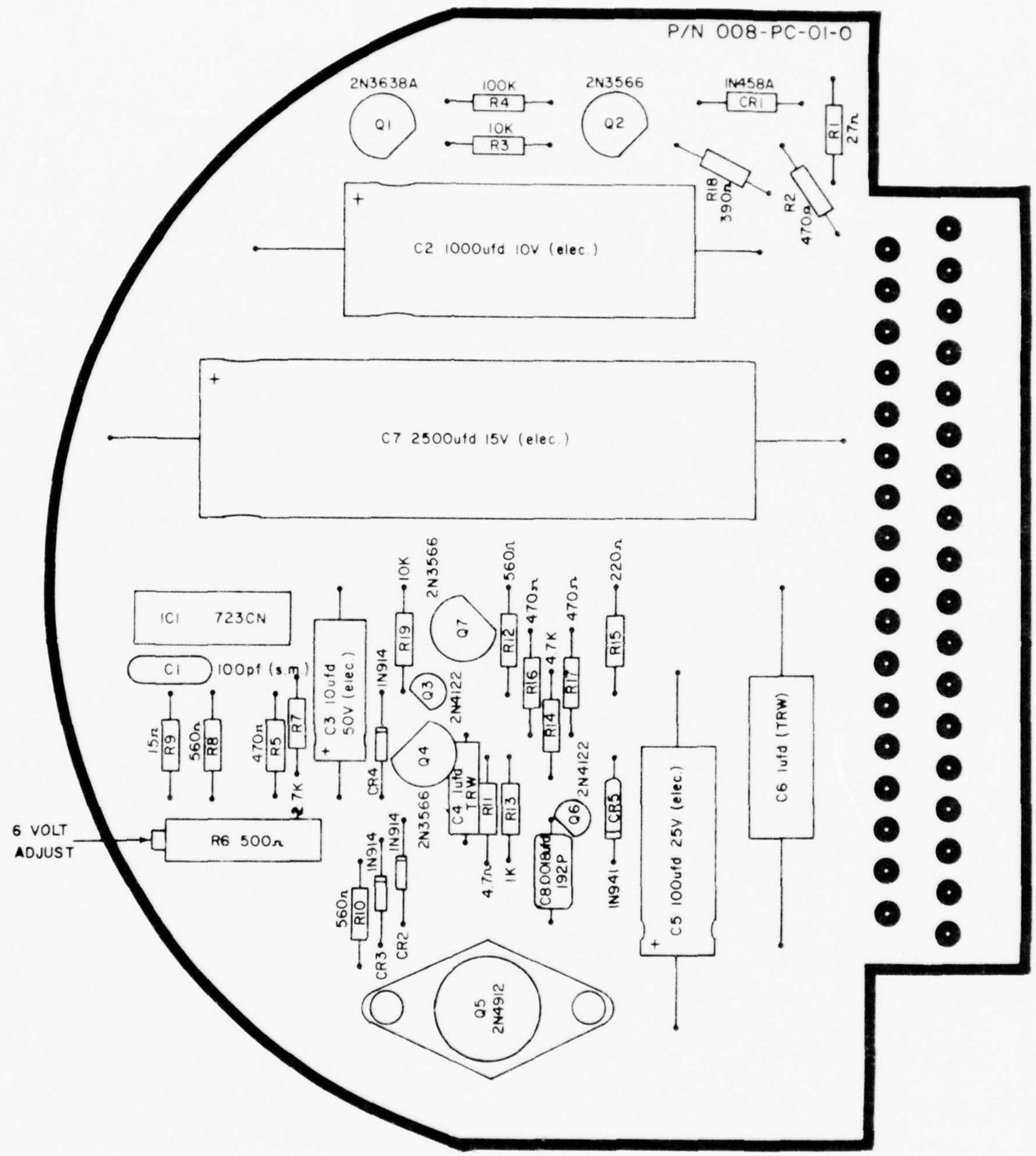
CTD UNDERWATER UNIT MK III <u>POWER SUPPLY</u>

Fig. 5.1.6(2)



U.W.U. POWER SUPPLY

CTD Underwater Unit MK III
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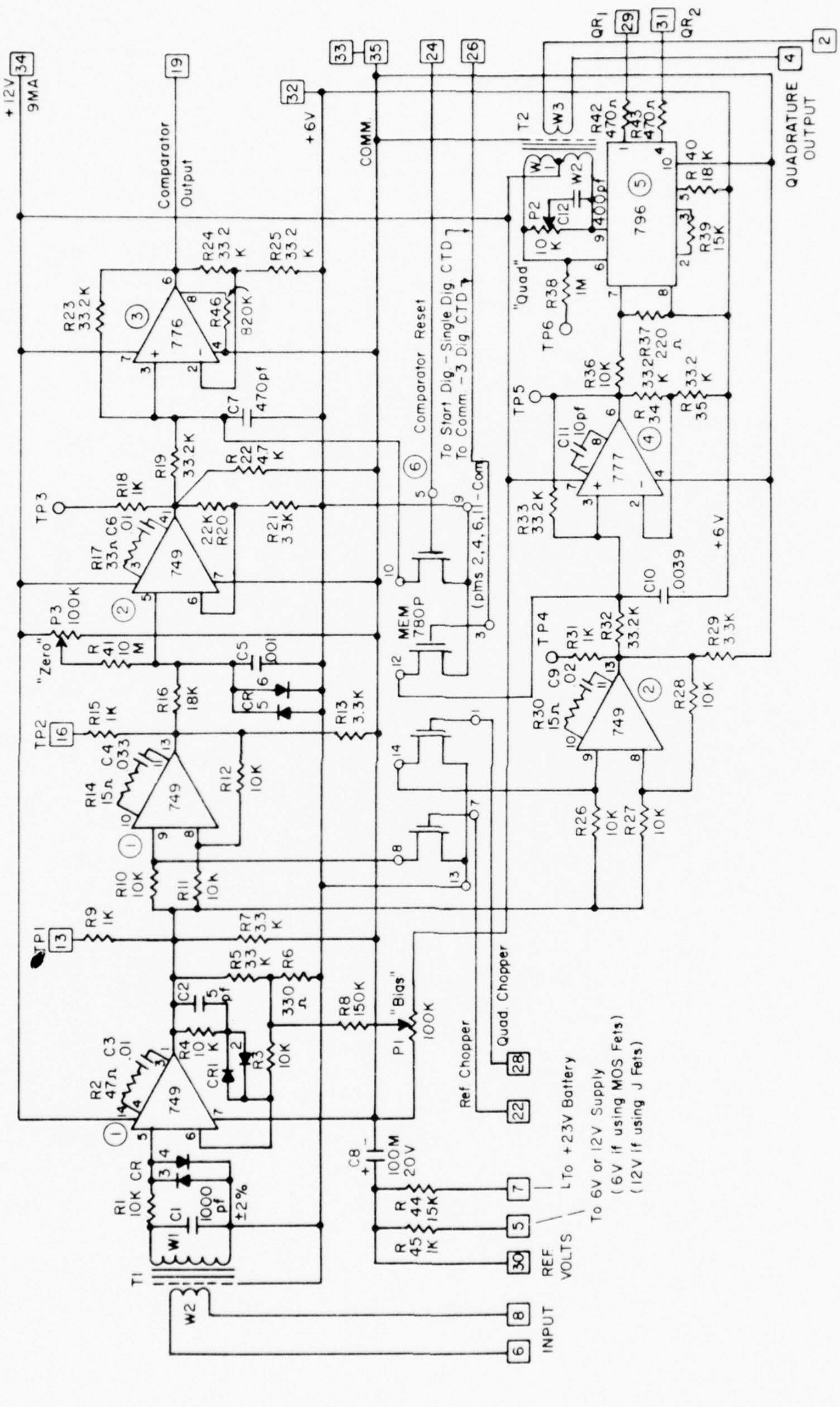
Fig. 5.1.6(3)

Board Title POWER SUPPLY Board Number 06

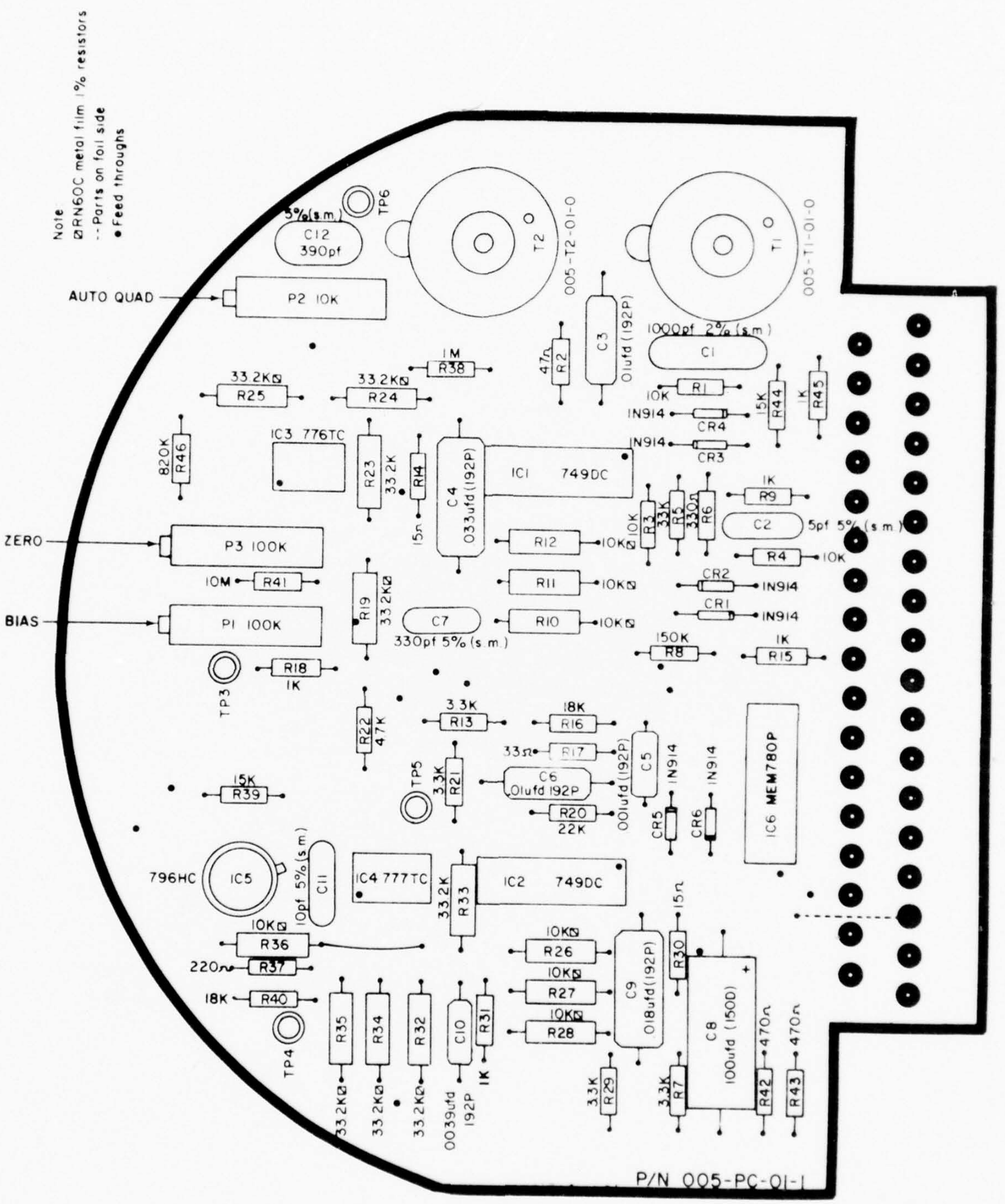
Pin #	Function	Connected To	Color	Harness Postn. L	C	R	Twisted With	Shielded & Twisted Pair With	Source
1	+22V IN	End Plate P.S.	red	X					
2	SWITCH	End Plate 0603	wh	X					
3	COMMON	0602	blk	X					X
4	COMMON			X					X
5	COMMON			X					X
6	COMMON			X					X
7	COMMON			X					X
8	COMMON			X					X
9	COMMON			X					X
10	COMMON			X					X
11	COMMON	0535	blk	X					X
12	COMMON	0735	blk	X					X
13	COMMON	0435	blk	X					X
14	COMMON	0835	blk	X					X
15	COMMON	0335	blk	X					X
16	COMMON	0935	blk	X					X
17	COMMON	0235	blk	X					X
18	COMMON	1335	blk	X					X
19	COMMON	0135	blk	X					X
20	+6V			X					X
21	+6V			X					X
22	+6V			X					X
23	+6V			X					X
24	+6V	0732	orn	X			0630, 0612		X
25	+6V			X					X
26	+6V	1132	orn	X					X
27	+6V			X					X
28	+6V			X					X
29	+6V	0332	orn	X			0633, 0615		X
30	+12V	0734, 0834	red	X			0612, 0614		X
31	+12V	0534, 0434	red	X			0611, 0613		X
32	+12V	0934	red	X			0616		X
33	+12V	0434, 0334	red	X			0613, 0615		X
34	+12V	1334	red	X			0618		X
35	+12V	0234, 0134	red	X			0617, 0619		X

Fig. 5.1.7



CTD UNDERWATER UNIT MK III A.C. COMPARATOR

Fig. 5.1.7(2)



A/C COMPARATOR

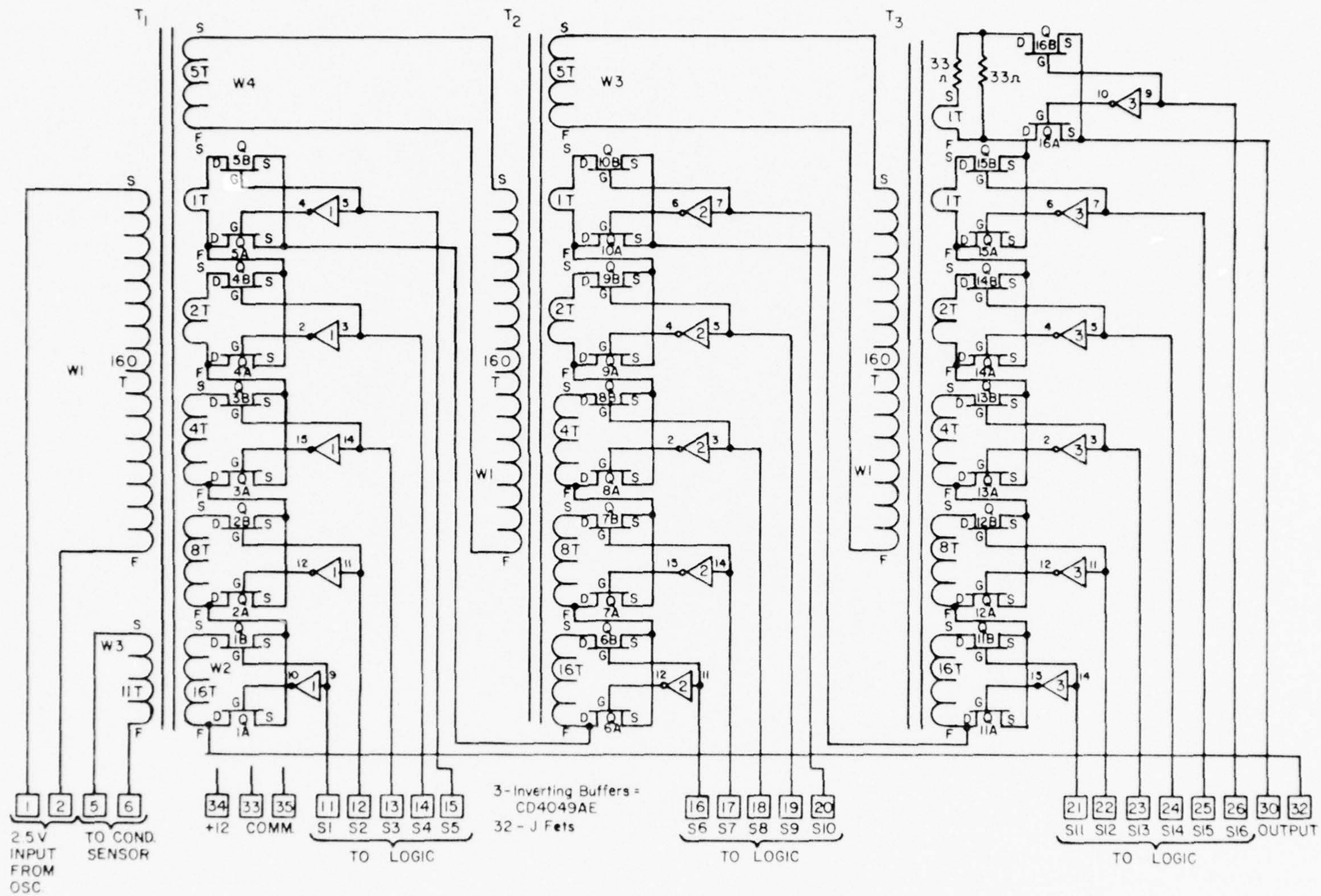
CTD Underwater Unit MK III
11/77

Fig. 5.1.7(3)

Board Title COMPARATOR Board Number 07

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1									
2	QUAD OUTPUT	0830	wh			X		COAX	X
3									
4	QUAD OUTPUT	0708	wh/red			X			X
5	12V	0734	red						
6	COMPARATOR I/P	0730, 0415	red/wh			X		COAX	
7	+22V	0601	blu	X					
8	COMPARATOR I/P	0704	wh/red						
9									
10									
11									
12									
13	T. P. #1	1113	wh/blu		X				X
14									
15									
16	T. P. #2								
17									
18									
19	COMPARATOR O/P	0905, 1105	blu		X				X
20									
21									
22	REF CHOP	1308, 0320	blu		X		0728		
23									
24	COMP. RESET	1104	brn		X				
25									
26	START DIG	0733, 0735	blk						
27									
28	QUAD CHOP	1304	grn		X		0722		
29	QUAD SINE	1329	orn			X	0731		
30	VOLTAGE REF	0415 0706, 0203, 0104	red						X
31	QUAD SINE	1330	wh			X	0729		
32	+6V	0627		X					
33	COMMON	0726, 0735	blk						
34	+12V	0630, 0705	red	X					
35	COMMON	0612, 0733	blk	X					

NBIS .

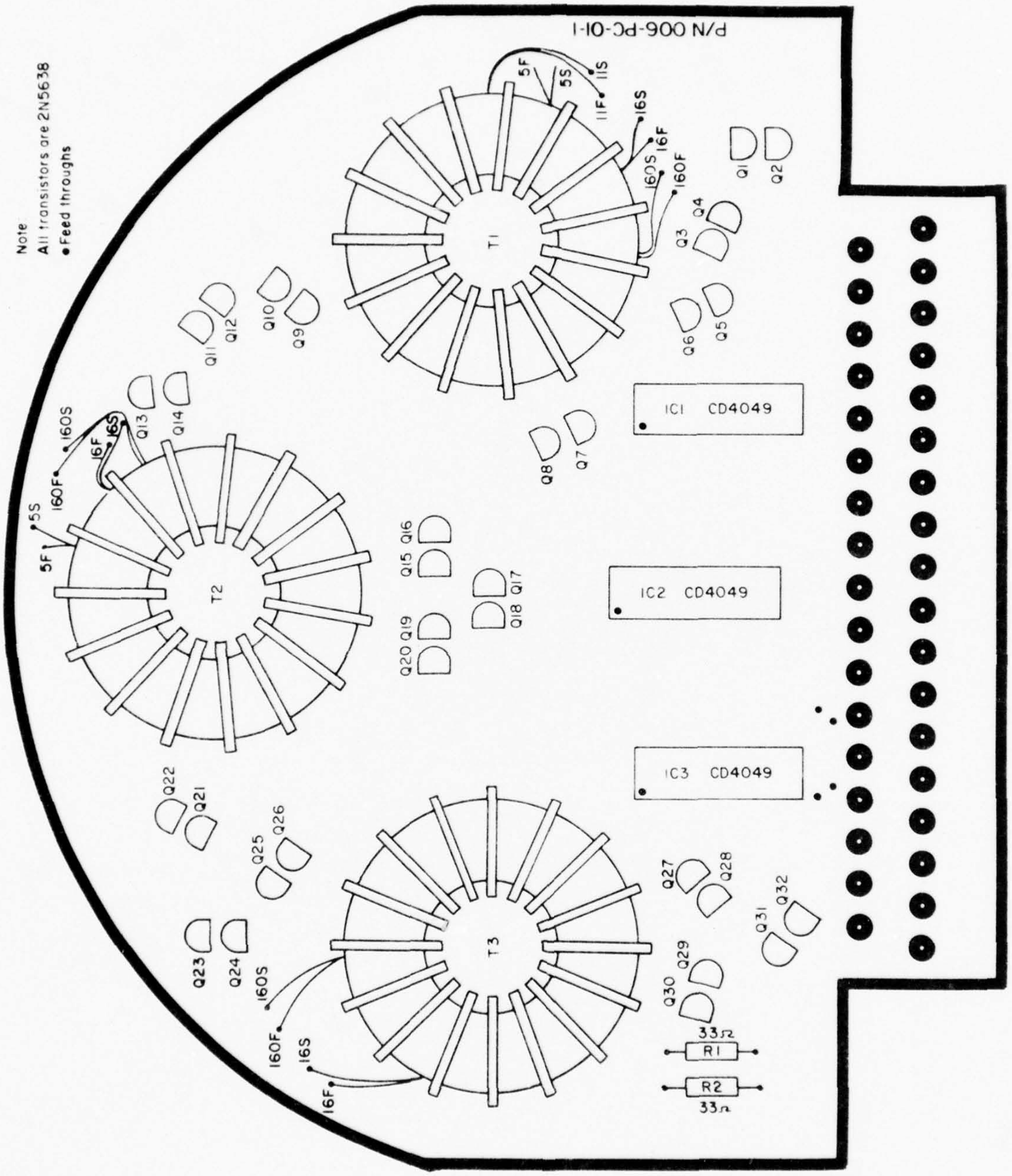


CTD UNDERWATER UNIT MK III D/A CONVERTER

Fig. 5.1.8

160

Fig. 5.1.8(2)



D/A CONVERTER

CTD Underwater Unit MK III

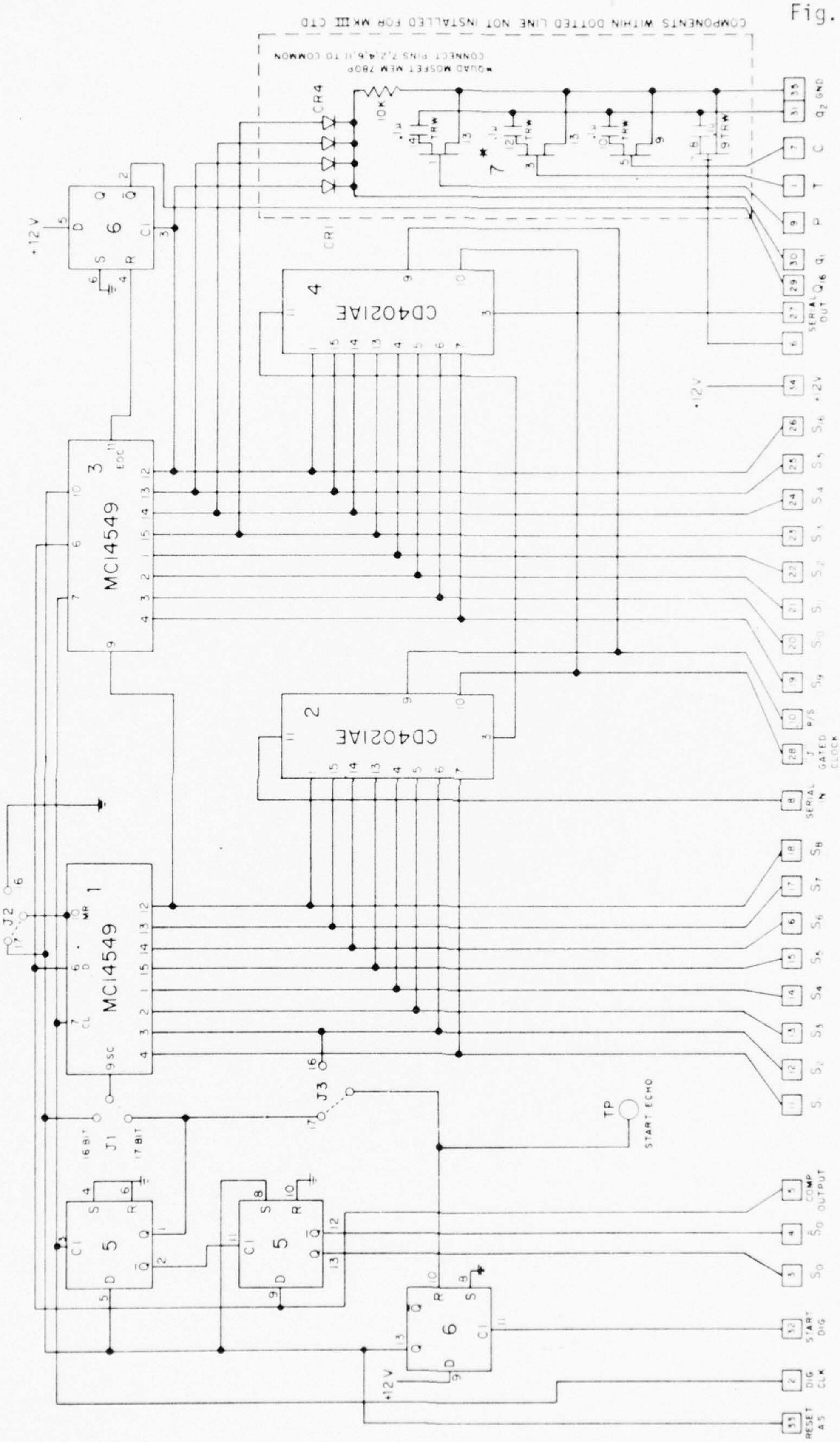
Fig. 5.1.8(3)

Board Title D/A CONVERT. Board Number 08

Pin	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	REF. $\overline{\text{SINE}}$	0129, 0214 1324, 0509, 040[illegible]	wh/blk			X	0802		
2	REF. SINE	0130, 0215 1323, 0308, 0401	wh/red			X	0801		
3									
4									
5	COND REF	0404	ylw			X	0806		X
6	COND REF	0406	brn			X	0805		X
7									
8									
9									
10									
11	BIT #1	0911, 1011	red						
12	BIT #2	0912, 1012	"						
13	BIT #3	0913, 1013	"						
14	BIT #4	0914, 1014	"						
15	BIT #5	0915, 1015	"						
16	BIT #6	0916, 1016	"						
17	BIT #7	0917, 1017	"						
18	BIT #8	0918, 1018	"						
19	BIT #9	0919, 1019	"						
20	BIT #10	0920, 1020	"						
21	BIT #11	0921, 1021	"						
22	BIT #12	0922, 1022	"						
23	BIT #13	0923, 1023	"						
24	BIT #14	0924, 1024	"						
25	BIT #15	0925, 1025	"						
26	BIT #16	0926, 1026	"						
27									
28									
29									
30	D/A OUTPUT	0702	wh			X		COAX	
31									
32	D/A OUTPUT	0207, 0102, 0104 0412, 0204,	wh			X		COAX	
33	COMMON	0835	link						
34	+12V	0631	red	X					
35	COMMON	0614, 0833	blk	X					

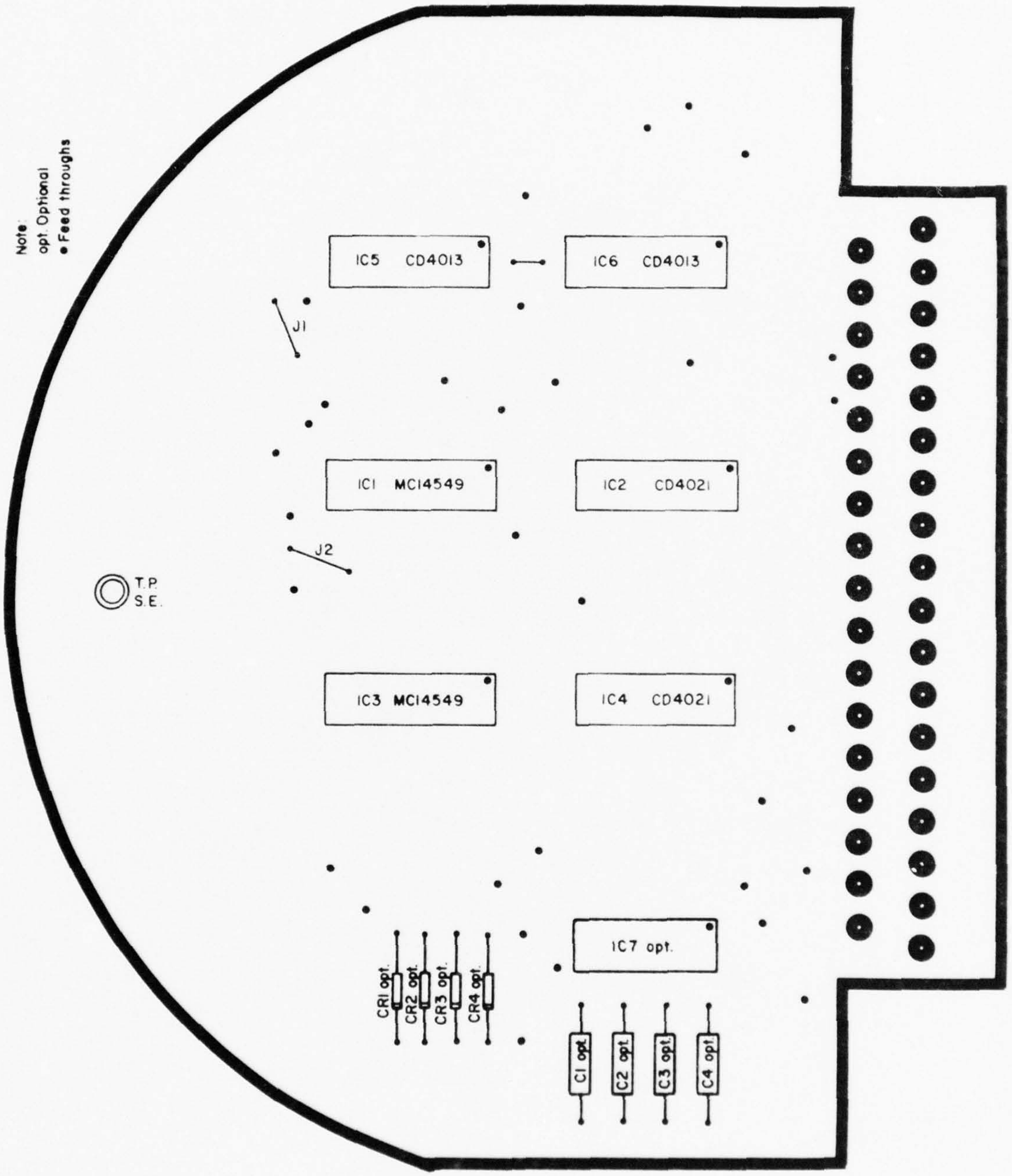
IS

Fig. 5.1.9



CTD UNDERWATER UNIT MK III DIGITIZER LOGIC

Fig. 5.1.9(2)



DIGITIZER LOGIC

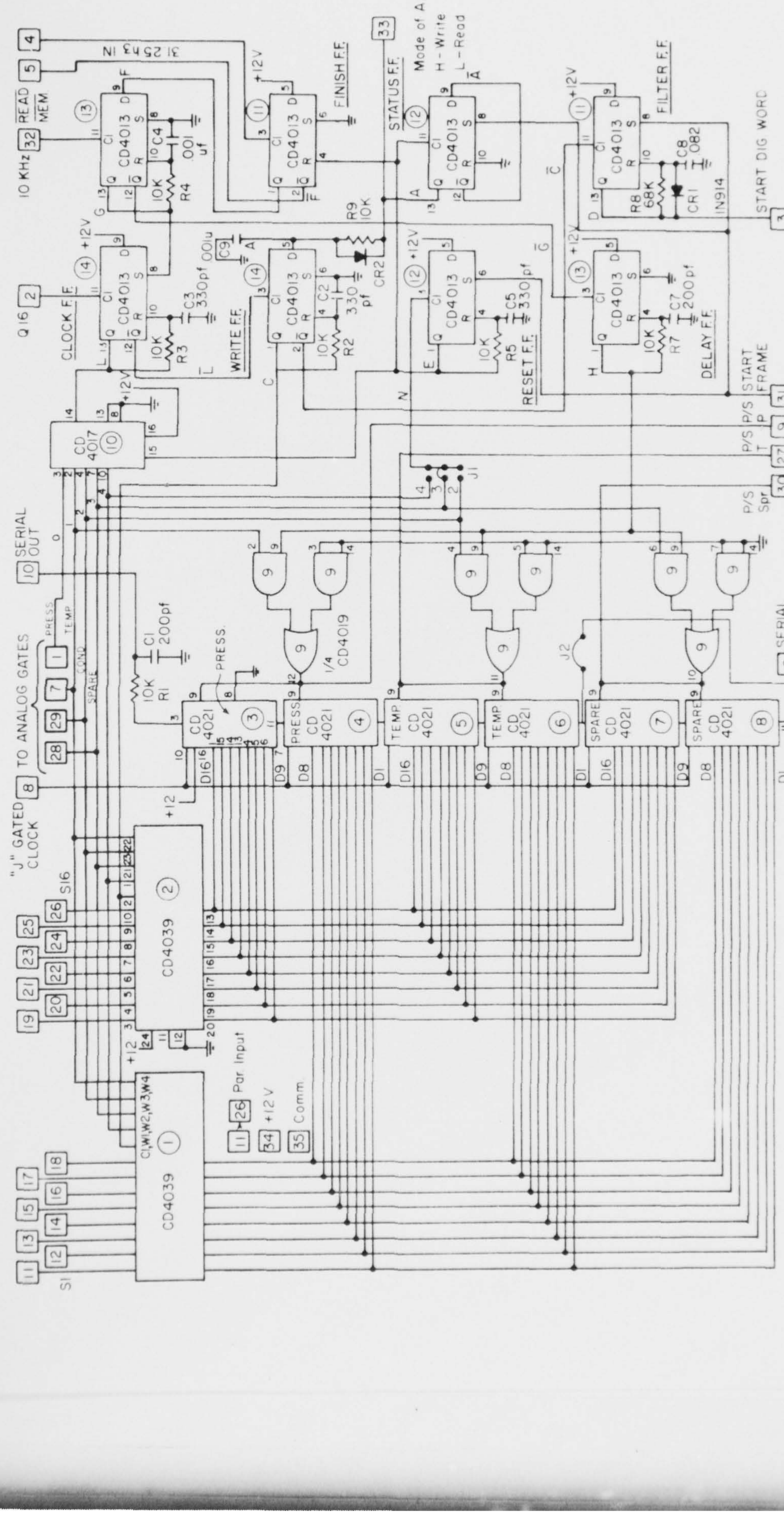
CTD Underwater Unit MK III

Fig. 5.1.9(3)

Board Title DIGI. LOGIC Board Number 09

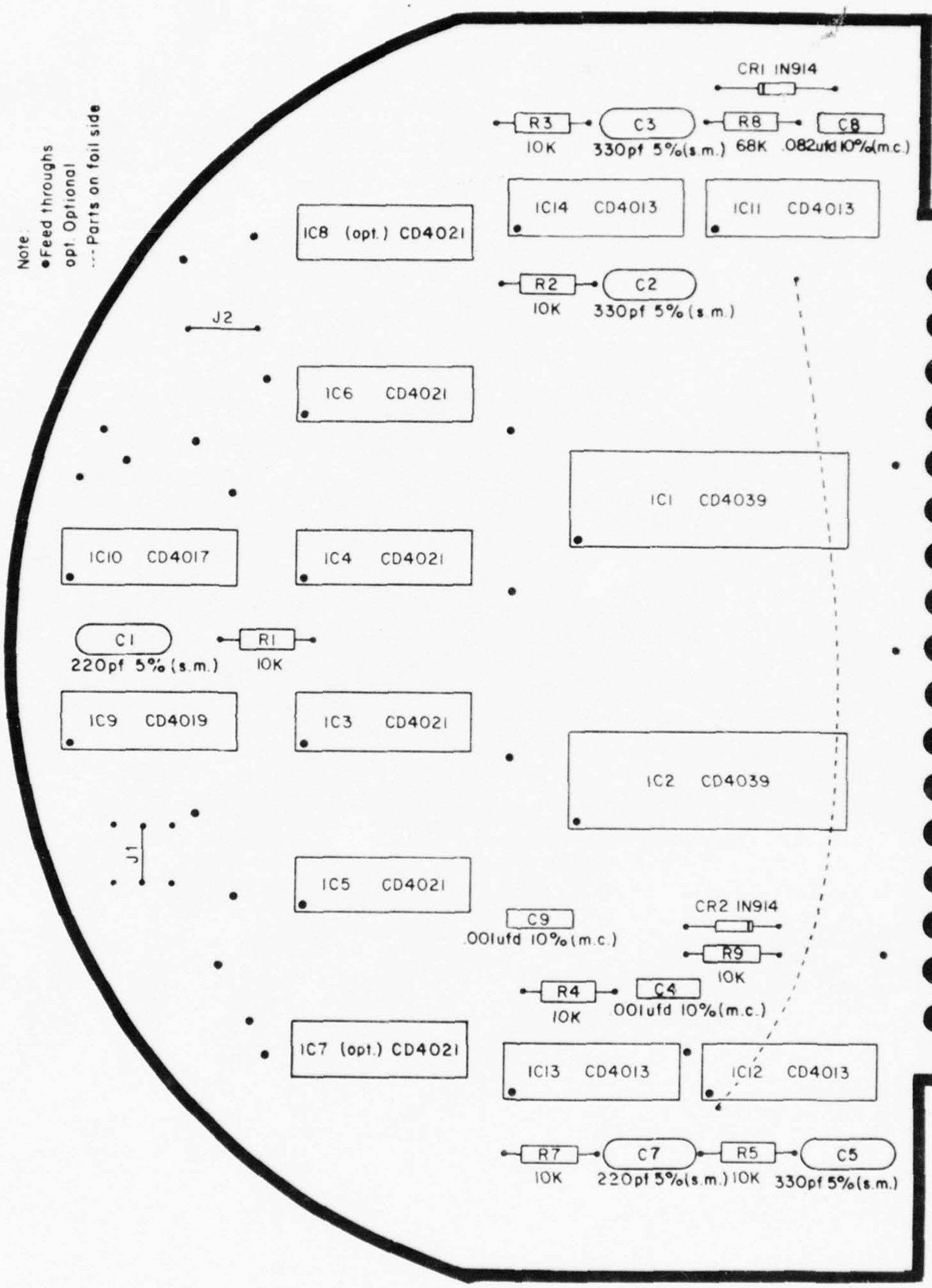
Pin #	Function	Connected To	Color	Harness Postn. L	C	R	Twisted With	Shielded & Twisted Pair With	Source
1	Q. MEM. T.				X				
2	DIGI CLK	1102	wh/grn		X				
3	S_0	0219, 0110	ylw		X				X
4	$\overline{S_0}$	0217, 1130, 0113	grn		X				X
5	COMP. OUTPUT	0719, 1105	blu		X				
6									
7	Q. MEM. C.				X				
8	SER. DATA IN	1106	gra		X				
9	W. MEM. P.				X				
10	P/S	1118, 0210	wh/grn		X				
11	BIT #1	1011, 0811	red						X
12	BIT #2	1012, 0812	"						X
13	BIT #3	1013, 0813	"						X
14	BIT #4	1014, 0814	"						X
15	BIT #5	1015, 0815	"						X
16	BIT #6	1016, 0816	"						X
17	BIT #7	1917, 0817	"						X
18	BIT #8	1018, 0818	"						X
19	BIT #9	1019, 0819	"						X
20	BIT #10	1020, 0820	"						X
21	BIT #11	1021, 0821	"						X
22	BIT #12	1022, 0822	"						X
23	BIT #13	1023, 0823	"						X
24	BIT #14	1024, 0824	"						X
25	BIT #15	1025, 0825	"						X
26	BIT #16	1026, 0826	"						X
27	SER DATA OUT	1006	wh/ylw		X				
28	GATED CLK	1117 1008, 0501, 1207	wh/blu		X				
29	Q 16	1002	red		X				X
30	Q. MEM. q1								
31	Q. MEM. q2								
32	START DIG	1003	brn						
33	A/S RESET	1133	ylw/wh						
34	+12V	0632, 1034	red	X					
35	COMMON	0616, 1035	blk	X					

Fig. 5.1.10



CTD UNDERWATER UNIT MK III MEMORY & MULTIPLEXER 12/77

Fig. 5.1.10(2)



MEMORY & MULTIPLEXER

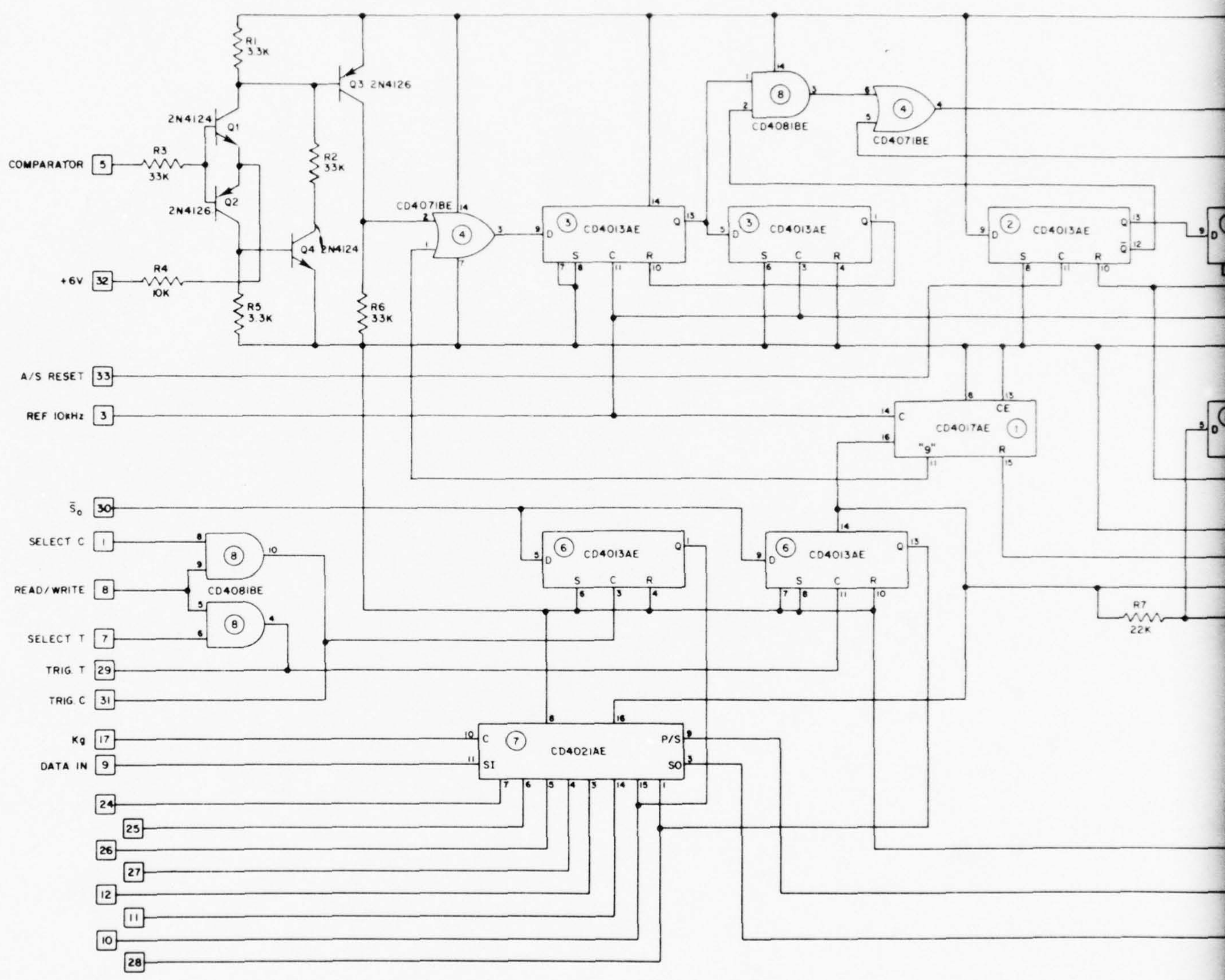
CTD Underwater Unit MK III

Fig. 5.1.10(3)

Board Title MEM + MULT. Board Number 10

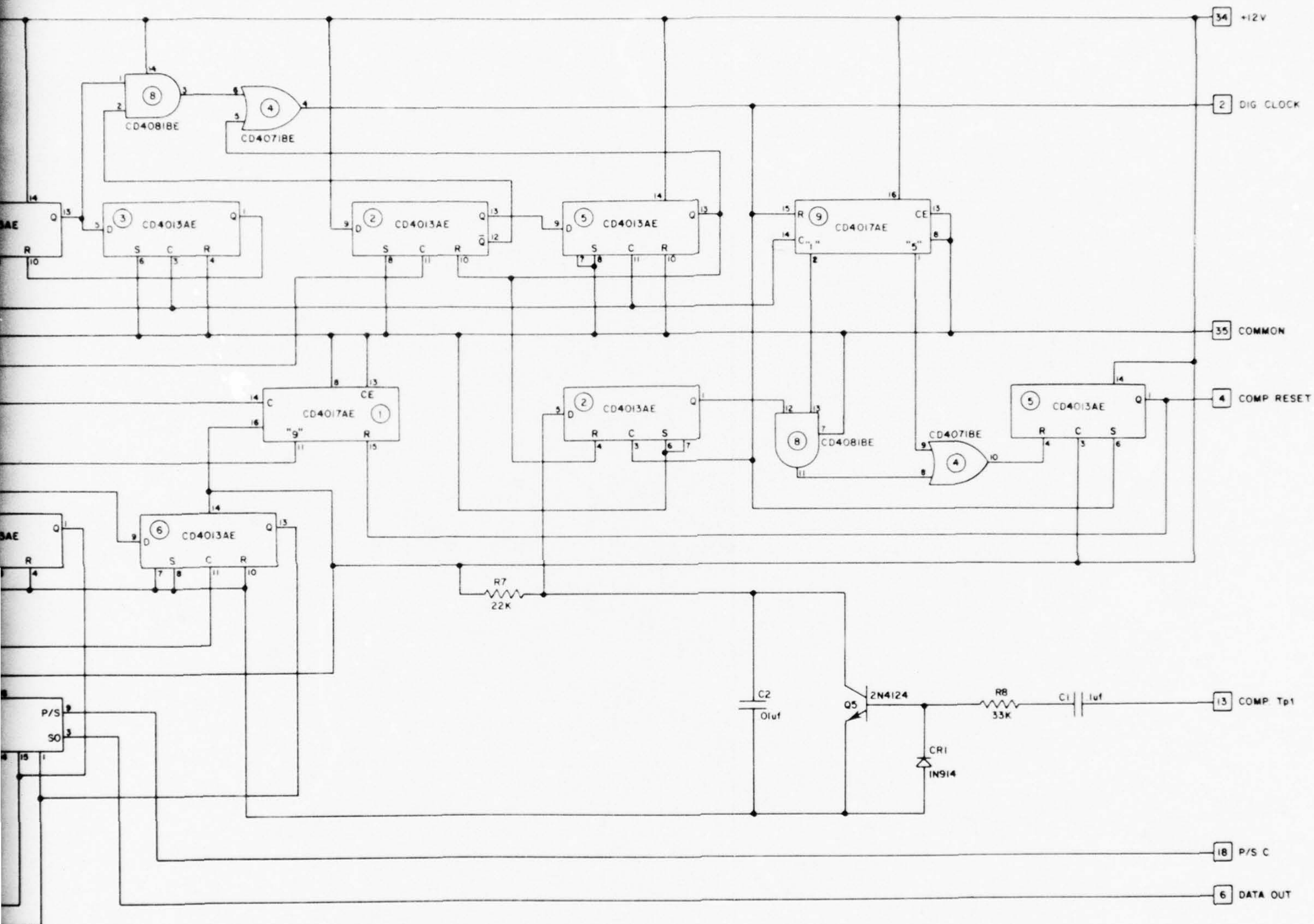
Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	SELECT P	0112	wh/ylw		X				X
2	Q 16	0929	red		X				
3	START DIG W	0932	brn		X				X
4	FRAME CLK	1303	wh/orn		X				
5	READ MEM.	1209	grn		X				
6	SER. DATA IN	0927	wh/ylw		X				
7	SELECT T.	1107, 0218 0928, 1207	wh/blk		X				X
8	GATED CLK.	0501, 1117	wh/blu		X				
9	P/S P.				X				X
10	SER. DATA OUT	1208	ylw		X				
11	BIT #1	0911	red						
12	BIT #2	0912	red						
13	BIT #3	0913	red						
14	BIT #4	0914	red						
15	BIT #5	0915	red						
16	BIT #6	0916	red						
17	BIT #7	0917	red						
18	BIT #8	0918	red						
19	BIT #9	0919	red						
20	BIT #10	0920	red						
21	BIT #11	0921	red						
22	BIT #12	0922	red						
23	BIT #13	0923	red						
24	BIT #14	0924	red						
25	BIT #15	0925	red						
26	BIT #16	0926	red						
27	P/S T.				X				X
28	SELECT SPARE				X				
29	SELECT C.	1101, 0411	wh		X				X
30	P/S SPARE				X				X
31	START FRAME	1216	blu		X				
32	REF. CHOP	1103, 1309, 0322	gra		X				
33	READ/WRITE	1108	vio		X				X
34	+12V	1134	red	X					
35	COMMON	0935	blk	X					

NBIS



CTD UNDERWATER UNIT MK III ADAPTIVE SAM

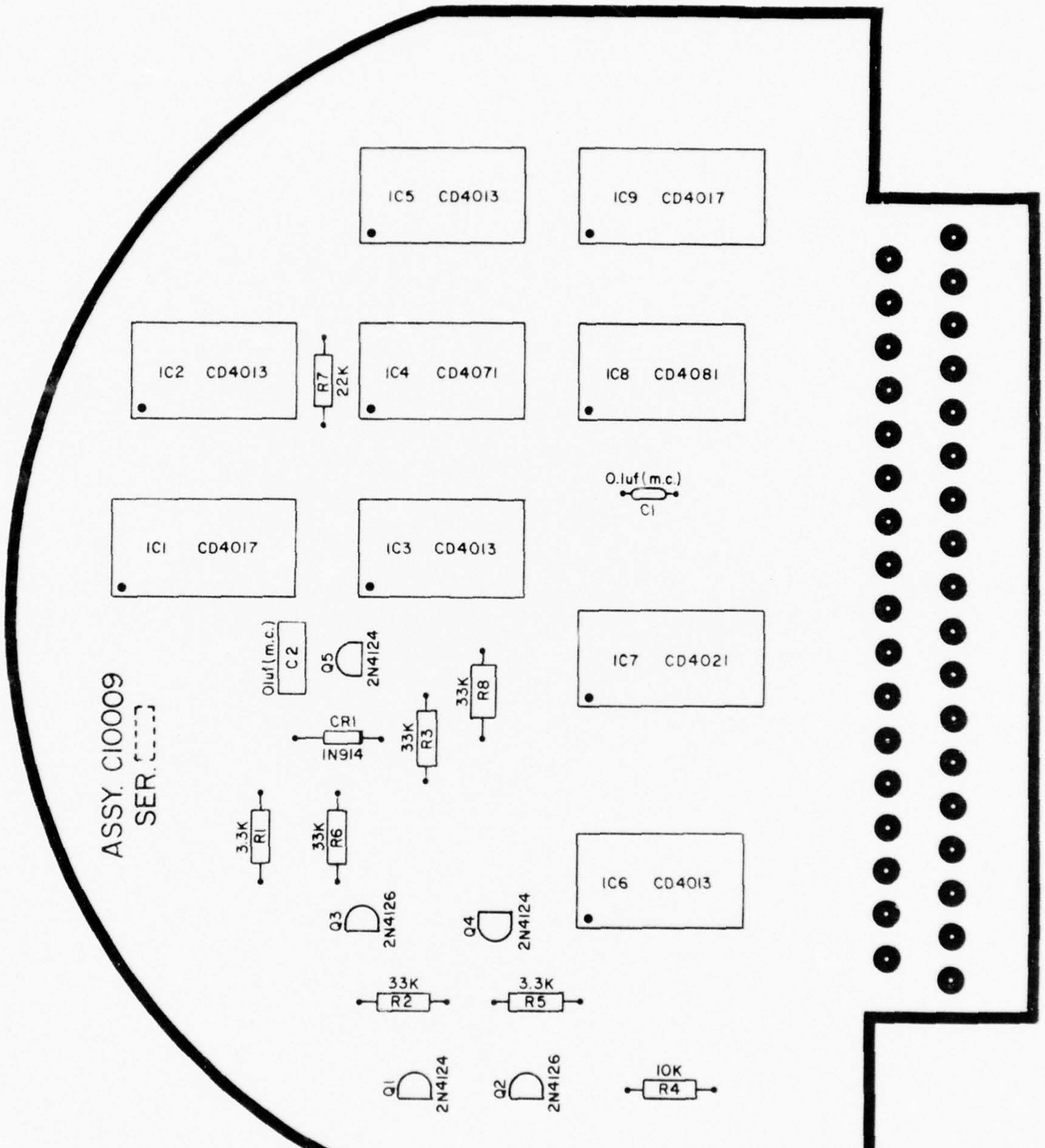
Fig. 5.1.11



CTD UNDERWATER UNIT MK III ADAPTIVE SAMPLING

12/77

Fig. 5.1.11(2)



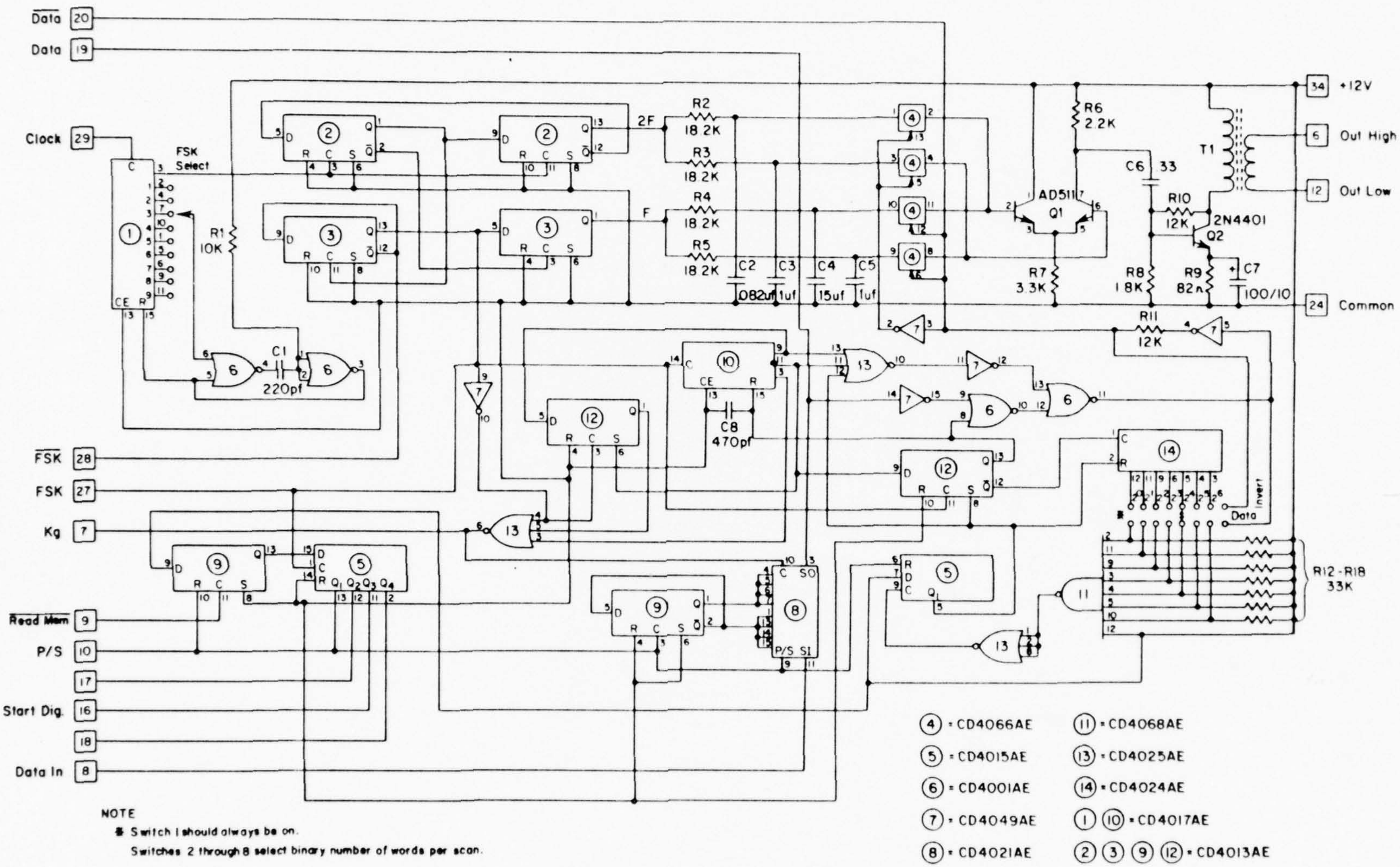
ADAPTIVE SAMPLING

CTD Underwater Unit

Fig. 5.1.11(3)

Board Title ADAPT. SAMP. Board Number 11

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	SELECT C.	1029, 0411	wh		X				
2	DIGI. CLOCK	0902	wh/grn		X				X
3	REF CHOP	1032, 0322, 1309	gra		X				
4	COMP. RESET	0724	grn		X				X
5	COMP. O/P	0719, 0905	blu		X				
6	SER. DATA OUT	0908	gra		X				
7	SELECT T.	1007, 0218	wh/blk		X				
8	READ/WRITE	1033	vio		X				X
9	SER. DATA IN	0514, 0502	ylw		X				
10	T. SIGN BIT								
11	SPARE I/P	0509	gra						
12	SPARE I/P	1124	blk						
13	COMP. T.P.#1	0713	wh/blu		X				
14									
15									
16									
17	GATED CLK.	0501, 0928 1207, 1008	wh/blu		X				
18	PARALLEL SHIFT	0910, 1210	wh/brn		X				
19									
20									
21									
22									
23									
24	SPARE I/P	1112, 1125	blk						
25	SPARE I/P	1124, 1126	blk						
26	SPARE I/P	1125, 1127	blk						
27	SPARE I/P	1126, 1135	blk						
28	PRESS. SIGN BIT								
29									
30	$\overline{S_0}$	0904, 0113, 0217	grn		X				
31									
32	+6V	0625	orn	X			1134, 1135		
33	A/S RESET	0933	ylw/wh		X				
34	+12V	1234		X			1132, 1135		
35	COMMON	1127, 1035		X			1132, 1134		



NOTE
Switch I should always be on.
Switches 2 through 8 select binary number of words per scan.

CTD UNDERWATER UNIT MK III TTY FORMATTER & FSK MODULATOR

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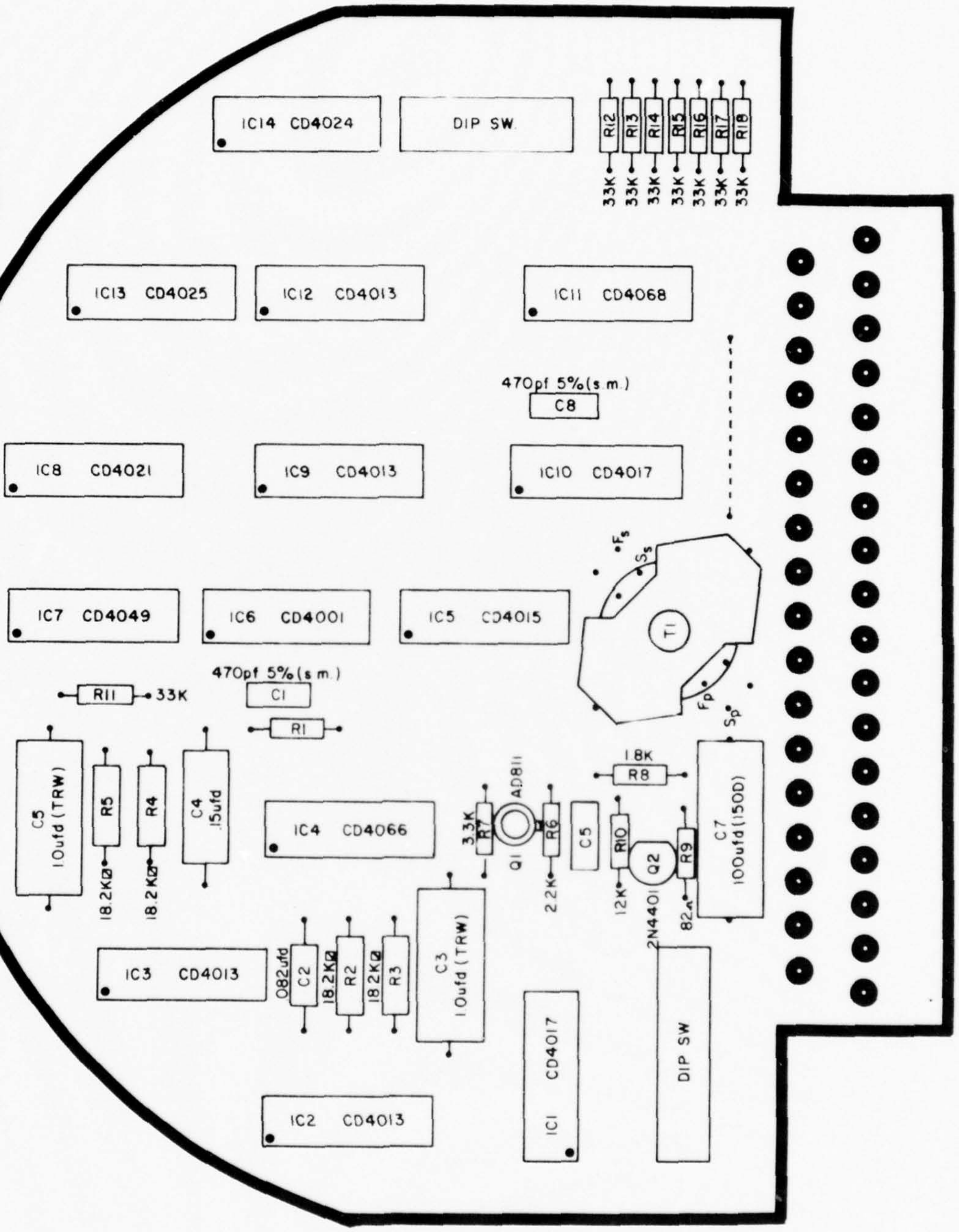
Fig. 5.1.12(2)

Note
t.b.d. To be determined
● Feed throughs
⌀ RN60C metal film 1% resistors
-- Parts on foil side



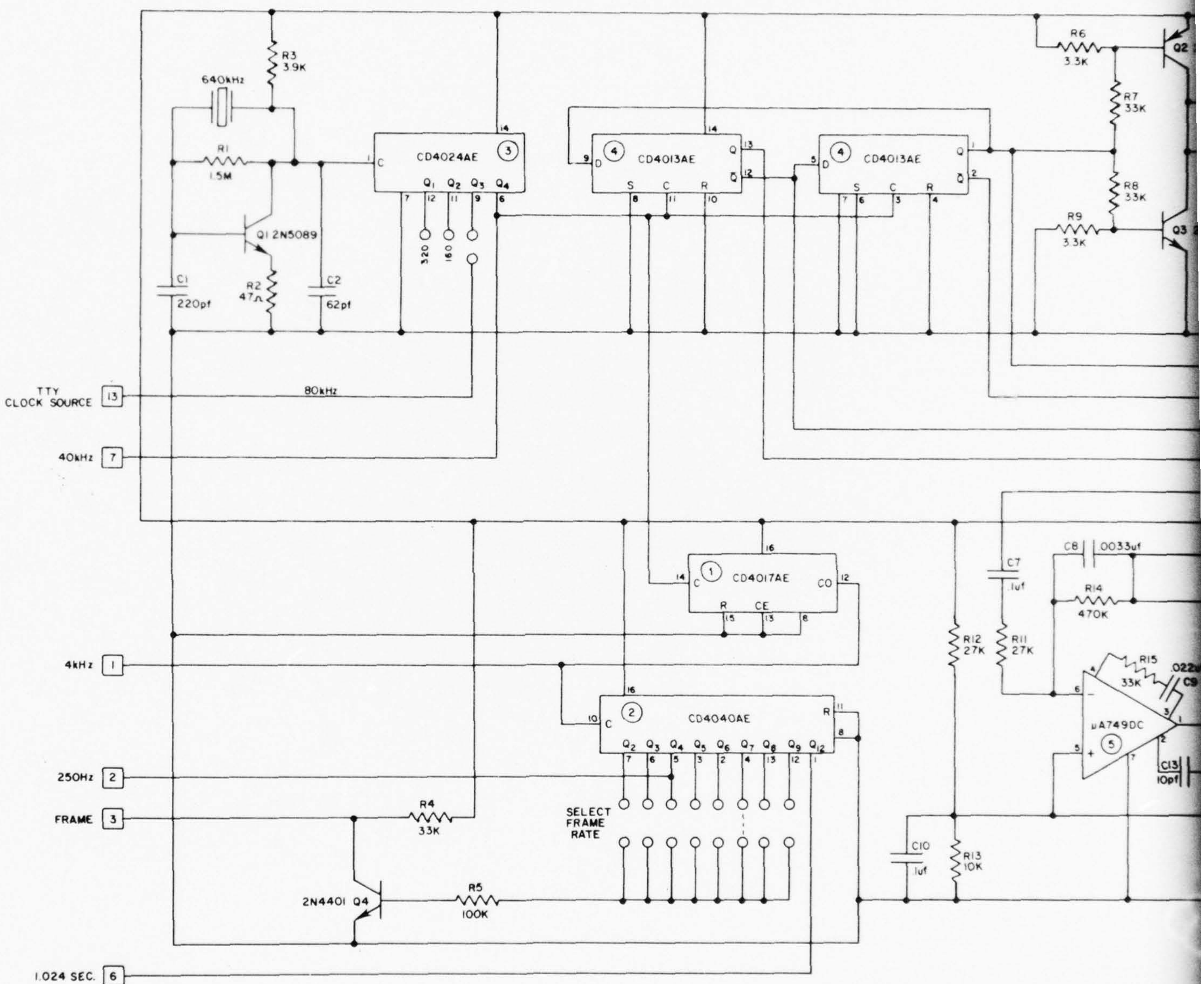
TTY FORMATTER & FSK MODULATOR

CTD Underwater Unit MK III

Fig. 5.1.12(3)

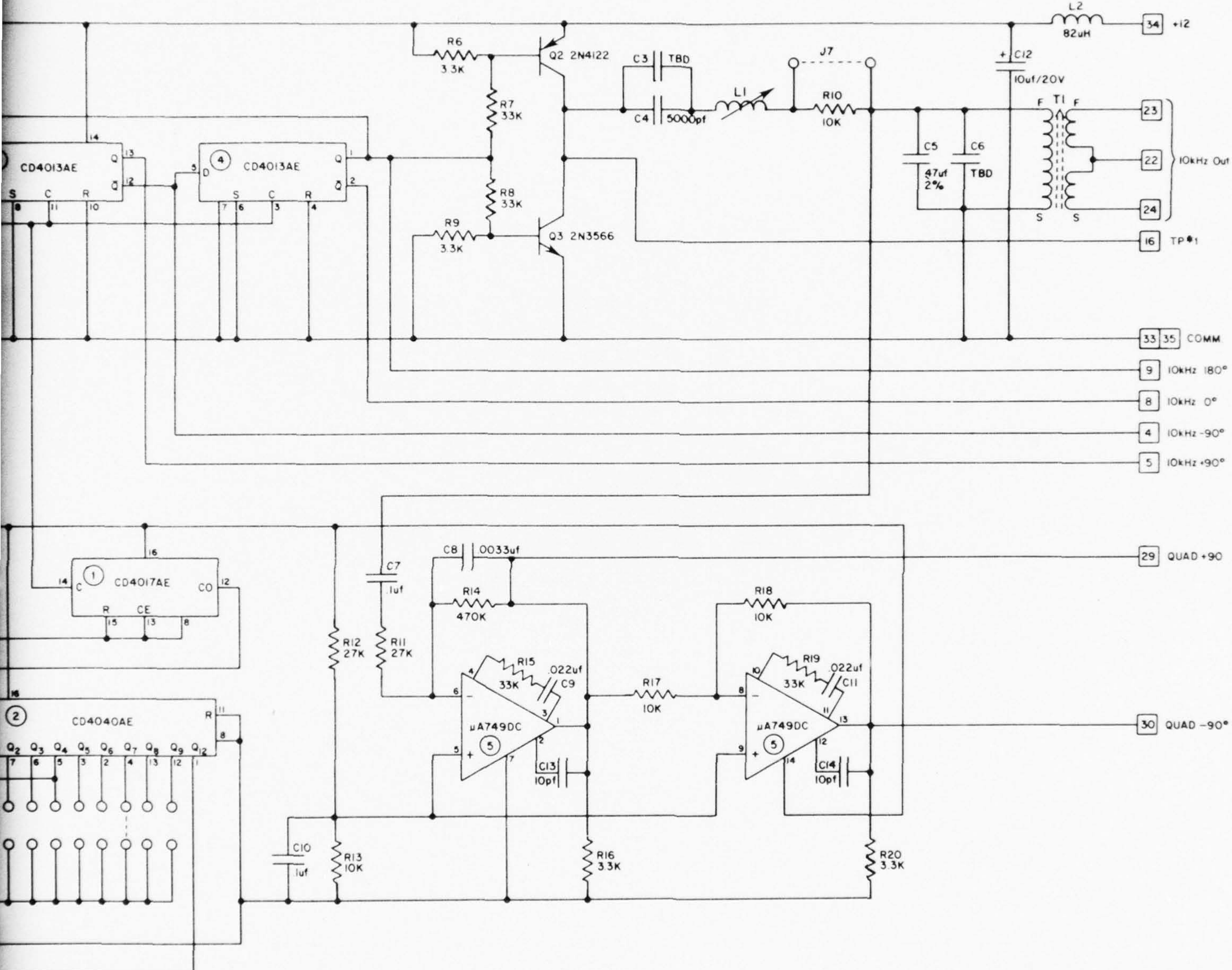
Board Title TTY-FSK Board Number 12

Pin #	Function	Connected To	Color	Harness Postn.			Twisted With	Shielded & Twisted Pair With	Source
				L	C	R			
1									
2									
3									
4									
5									
6	FSK HI	End Cap					1212		
7	GATED CLK.	1117, 1008, 0501, 0928	wh/blu		X				X
8	DATA IN	1010	ylw		X				
9	$\overline{\text{READ MEM}}$	1005	grn		X				
10	P/S	0910, 1118	wh/brn		X				X
11									
12	FSK LO	End Cap					1206		
13									
14									
15									
16	START DIG.	1031	blu						X
17	Q2 SPARE								
18	Q4 SPARE								
19	DATA								
20	$\overline{\text{DATA}}$								
21									
22									
23									
24									
25									
26									
27	FSK CLK								
28	$\overline{\text{FSK}}$ CLK								
29	FREQ INPUT	1313, 0503	brn		X				
30									
31									
32									
33	COMMON	1235	link						
34	+12V	1134	red	X			1235		
35	COMMON	1135, 1233	blk	X			1234		



CTD UNDERWATER UNIT MK III SIGNAL GENERA

Fig. 5.1.13



CTD UNDERWATER UNIT MK III SIGNAL GENERATOR

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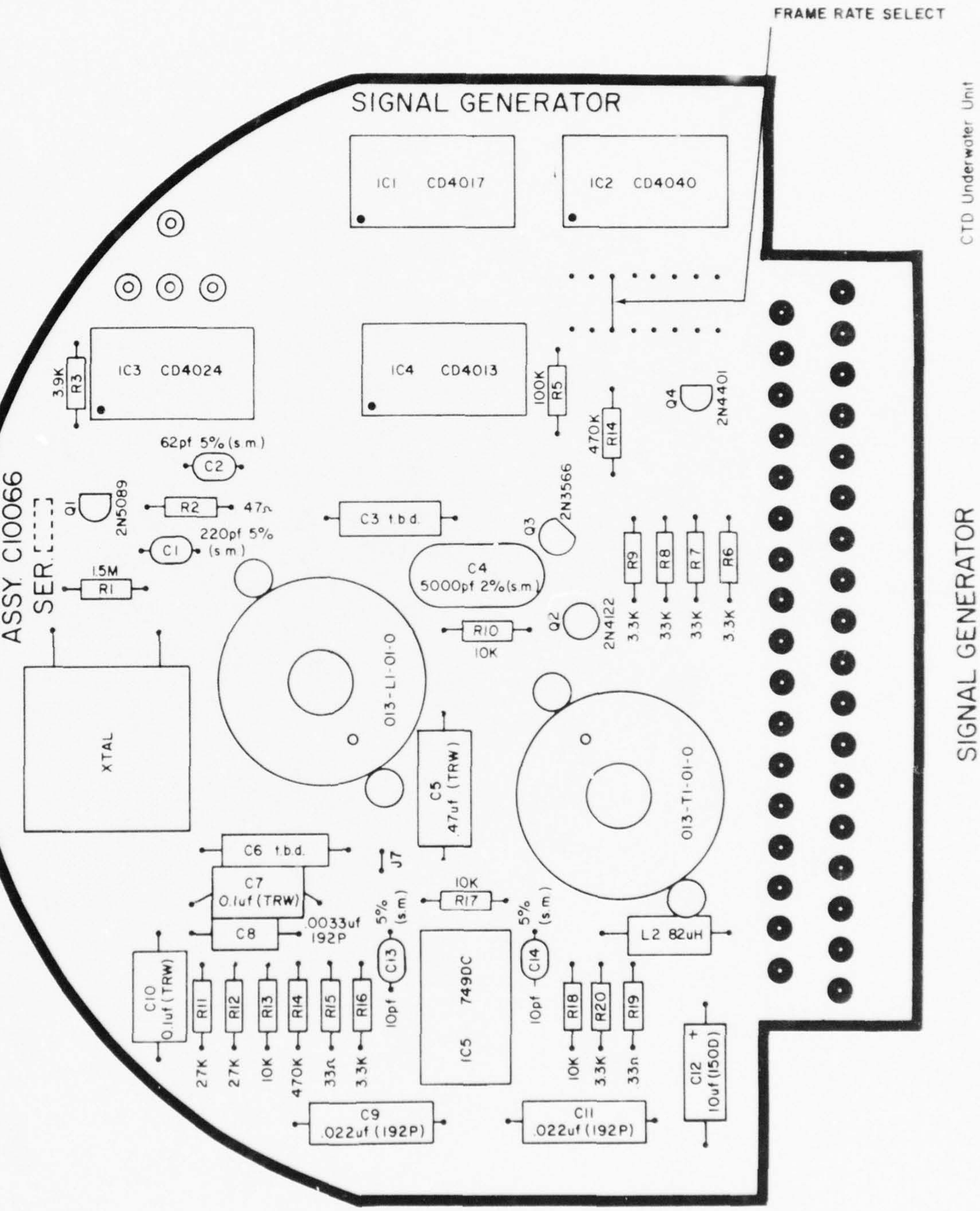
2

Fig. 5.1.13(2)

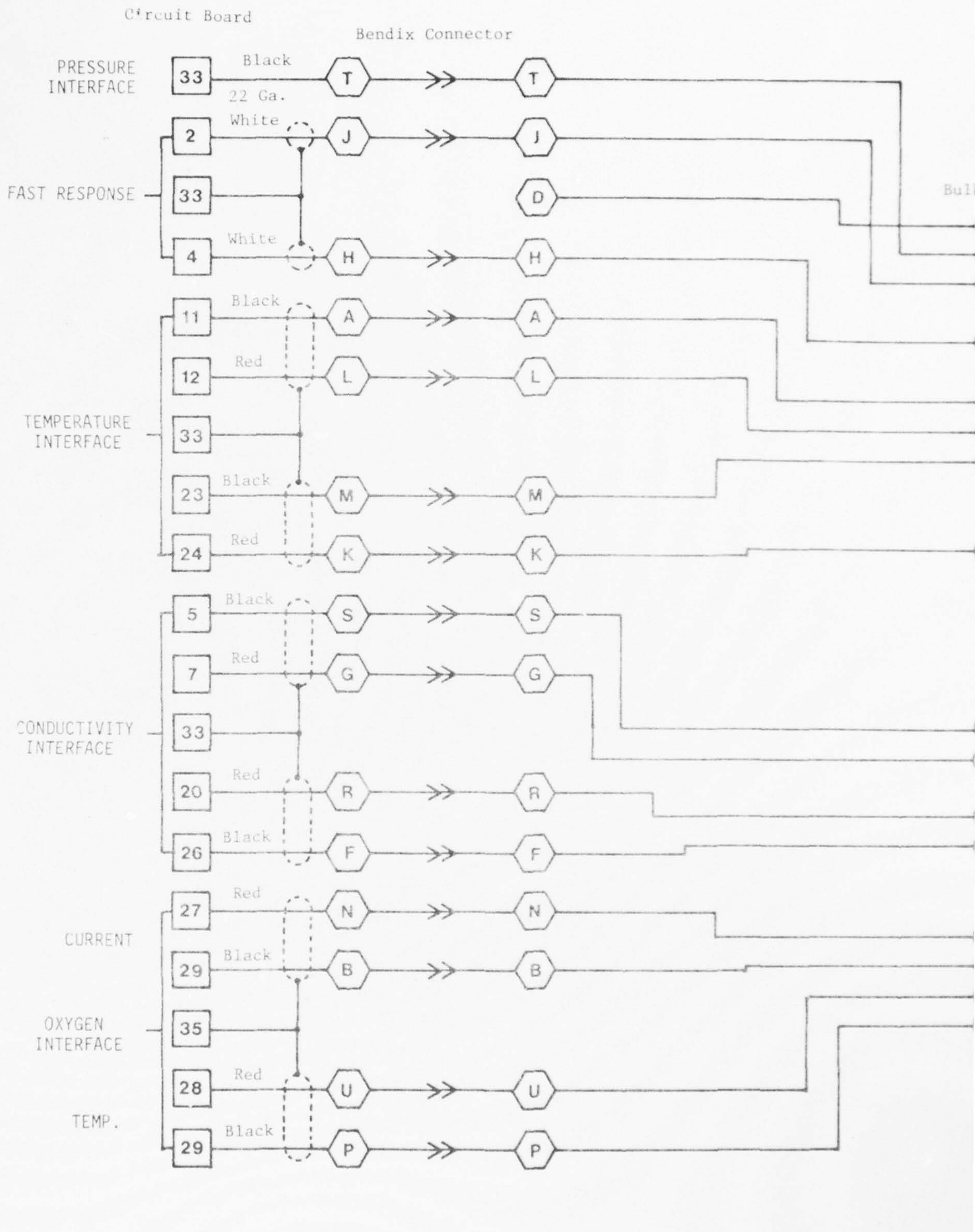


Note t.b.d To be determined

CTD Underwater Unit

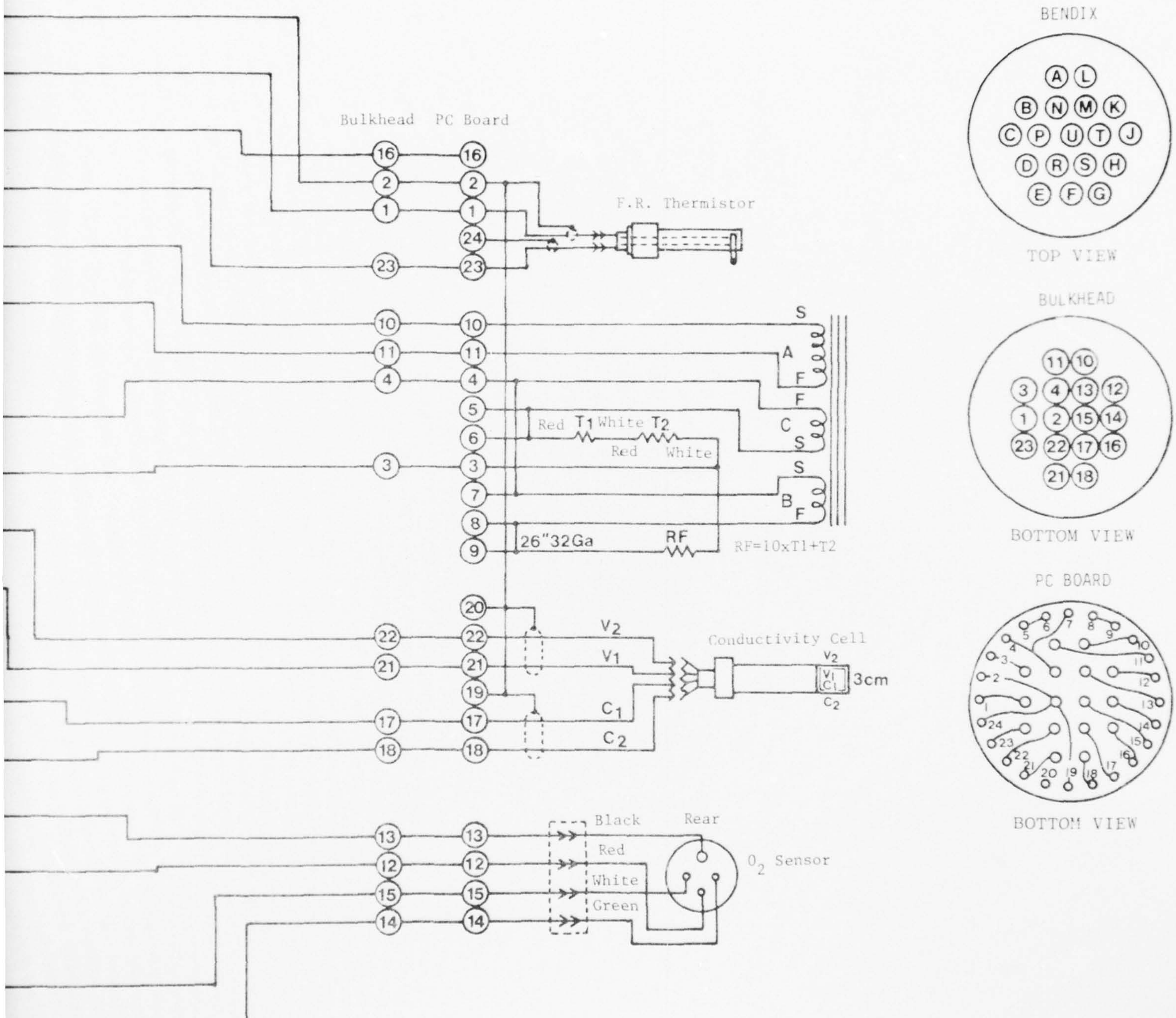
Board Title SIG. GEN. Board Number 13

Pin #	Function	Connected To	Color	Harness Postn. L	Harness Postn. C	Harness Postn. R	Twisted With	Shielded & Twisted Pair With	Source
1	4Khz	0526	wh		X				X
2	250 hz	0518	wh/vio		X				X
3	FRAME CLOCK	1004	wh/orn		X				X
4	QUAD CHOP	0728	grn		X		1308		X
5	QUAD $\overline{\text{CHOP}}$				X				X
6	1.024 SEC.	0508	gra						
7	40 Khz								
8	REF CHOP	0722, 0320			X		1304, 1309		X
9	REF $\overline{\text{CHOP}}$	0322, 1103, 1032	gra		X				X
10	COMP. RESET								X
11									
12									
13	160 Khz/80 Khz	1229	grn		X				X
14									
15									
16	T.P.#1								
17									
18									
19									
20									
21									
22	O/P SINE C.T.	0133, 0131, 0135	blk			X			X
23	REF SINE	0215, 0130, 0802 0401, 0308	wh/red			X			X
24	REF $\overline{\text{SINE}}$	0214, 0129, 0801 0403, 0309	wh/blk			X			X
25									
26									
27									
28									
29	QUAD $\overline{\text{SINE}}$	0729	orn			X			X
30	QUAD SINE	0731	wh			X			X
31									
32									
33	COMMON	1335	link						
34	+12V	0634	red				1335		
35	COMMON	0618, 1333	blk				1334		



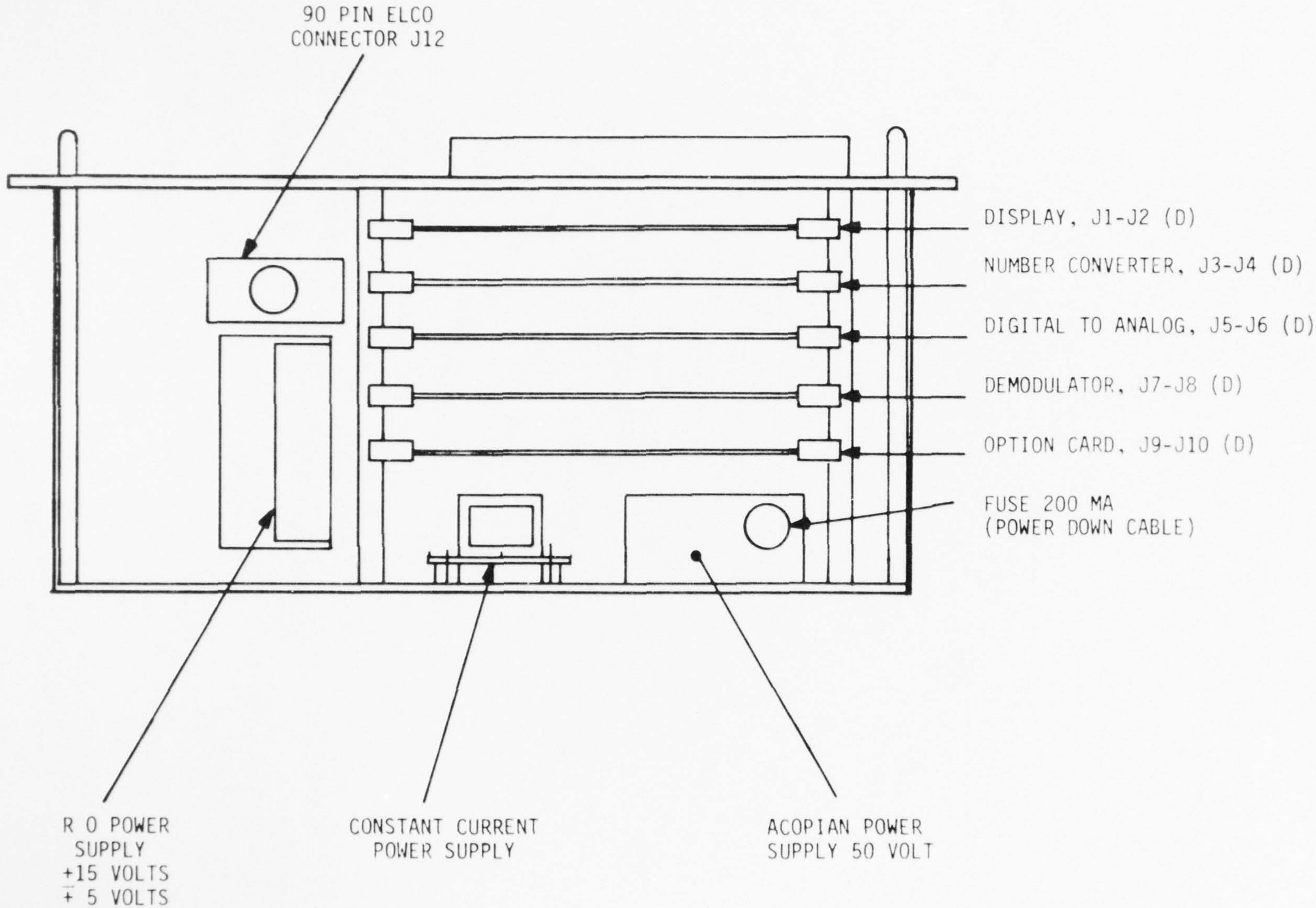
Circuit Board
Bendix Connector
PRESSURE INTERFACE
33
Black
22 Ga.
T
FAST RESPONSE
2
33
4
White
White
J
D
H
Bul
TEMPERATURE INTERFACE
11
12
33
23
24
Black
Red
Black
Red
A
L
M
K
CONDUCTIVITY INTERFACE
5
7
33
20
26
Black
Red
Red
Black
S
G
R
F
CURRENT
27
29
Red
Black
N
B
OXYGEN INTERFACE
35
TEMP.
28
29
Red
Black
U
P

Fig. 5.1.14



CTD SENSOR HEAD WIRING (CONNECTOR)

2



DECK DATA TERMINAL CHASSIS

Fig. 5.2

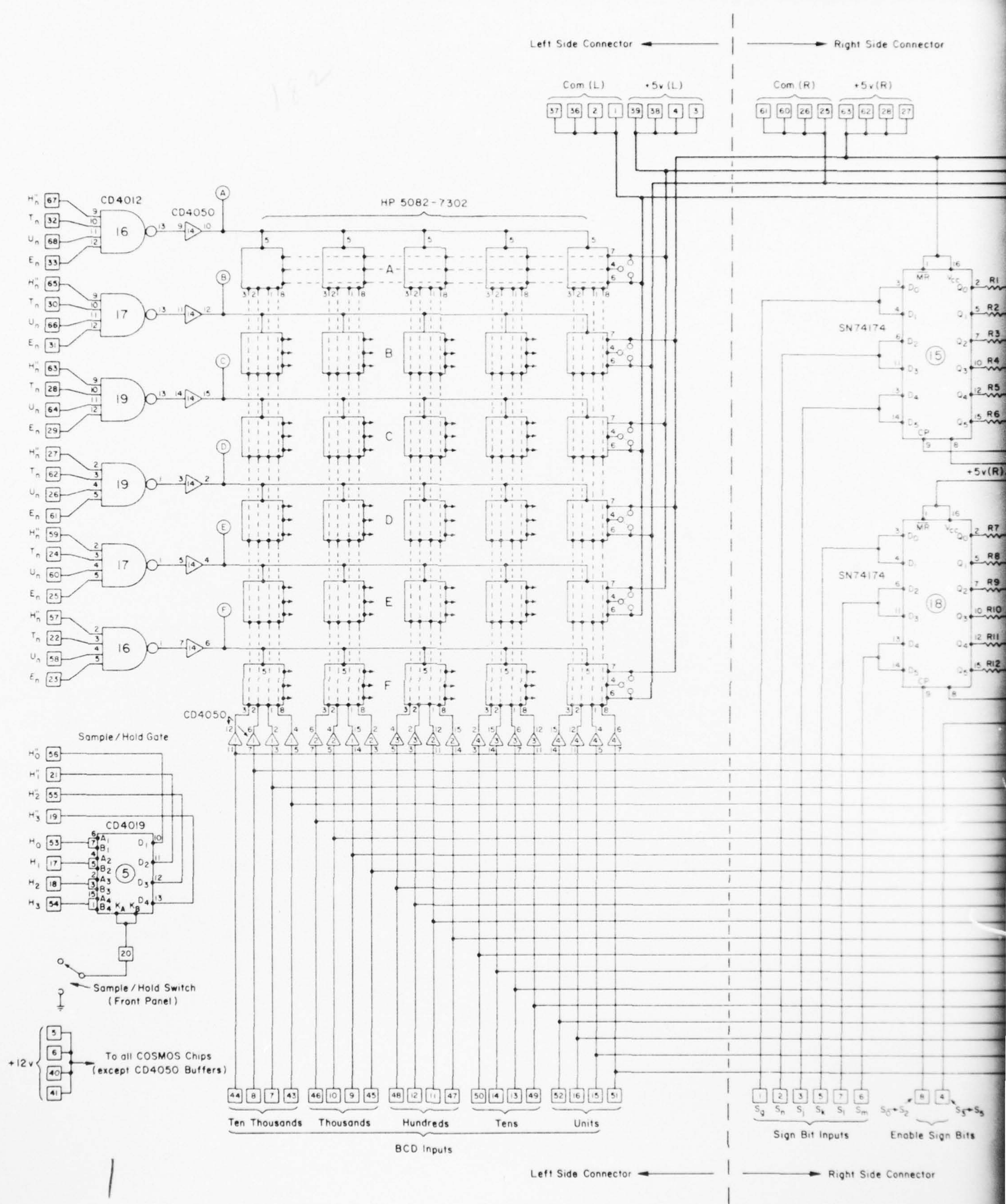
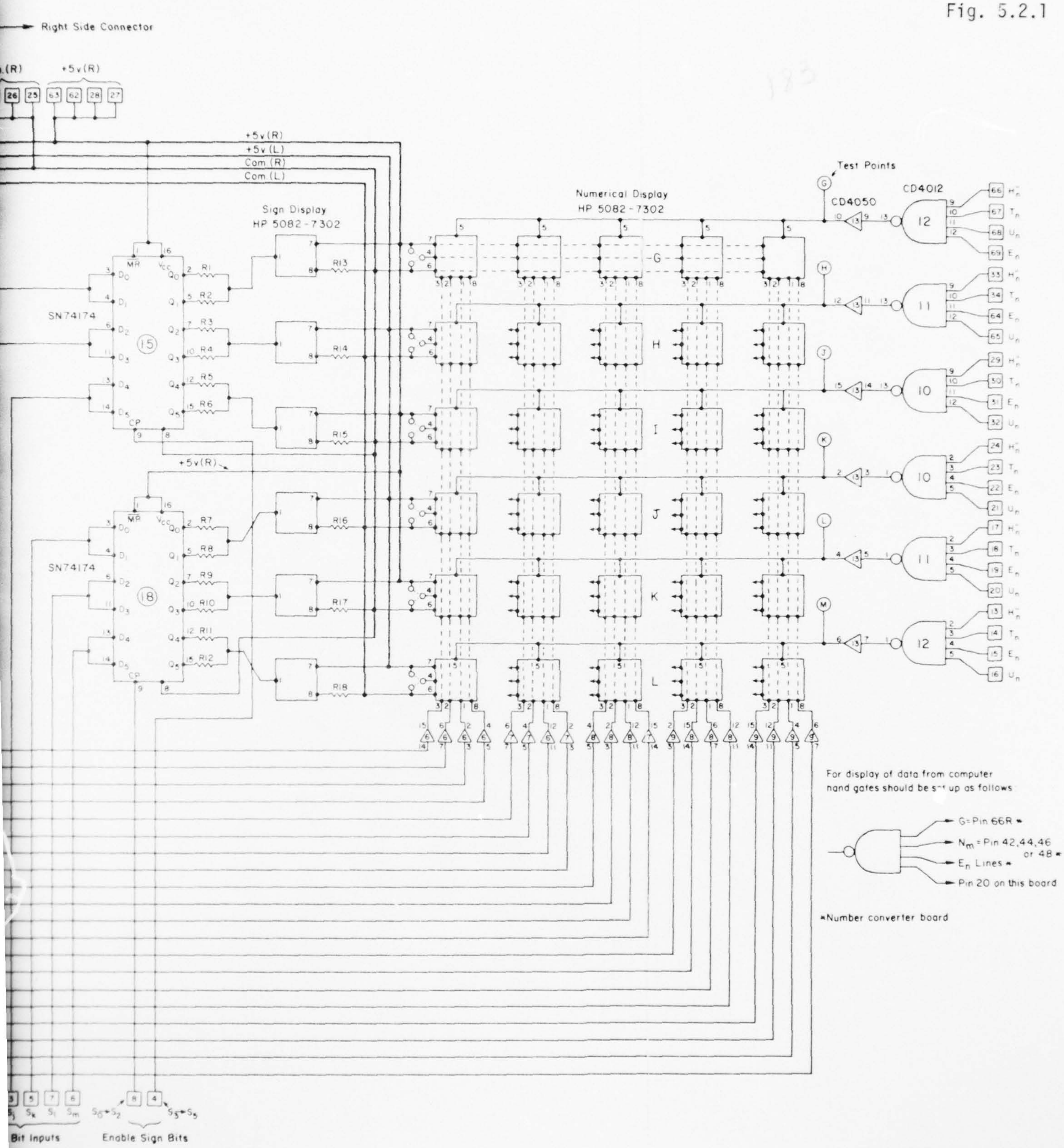

Left Side Connector
Right Side Connector
Com (L)
+5v (L)
Com (R)
+5v (R)
HP 5082-7302
CD4012
CD4050
SN74174
Sample / Hold Gate
CD4019
Sample / Hold Switch (Front Panel)
+12v
To all COSMOS Chips (except CD4050 Buffers)
Ten Thousands
Thousands
Hundreds
Tens
Units
BCD Inputs
Sign Bit Inputs
Enable Sign Bits
Left Side Connector
Right Side Connector

Fig. 5.2.1

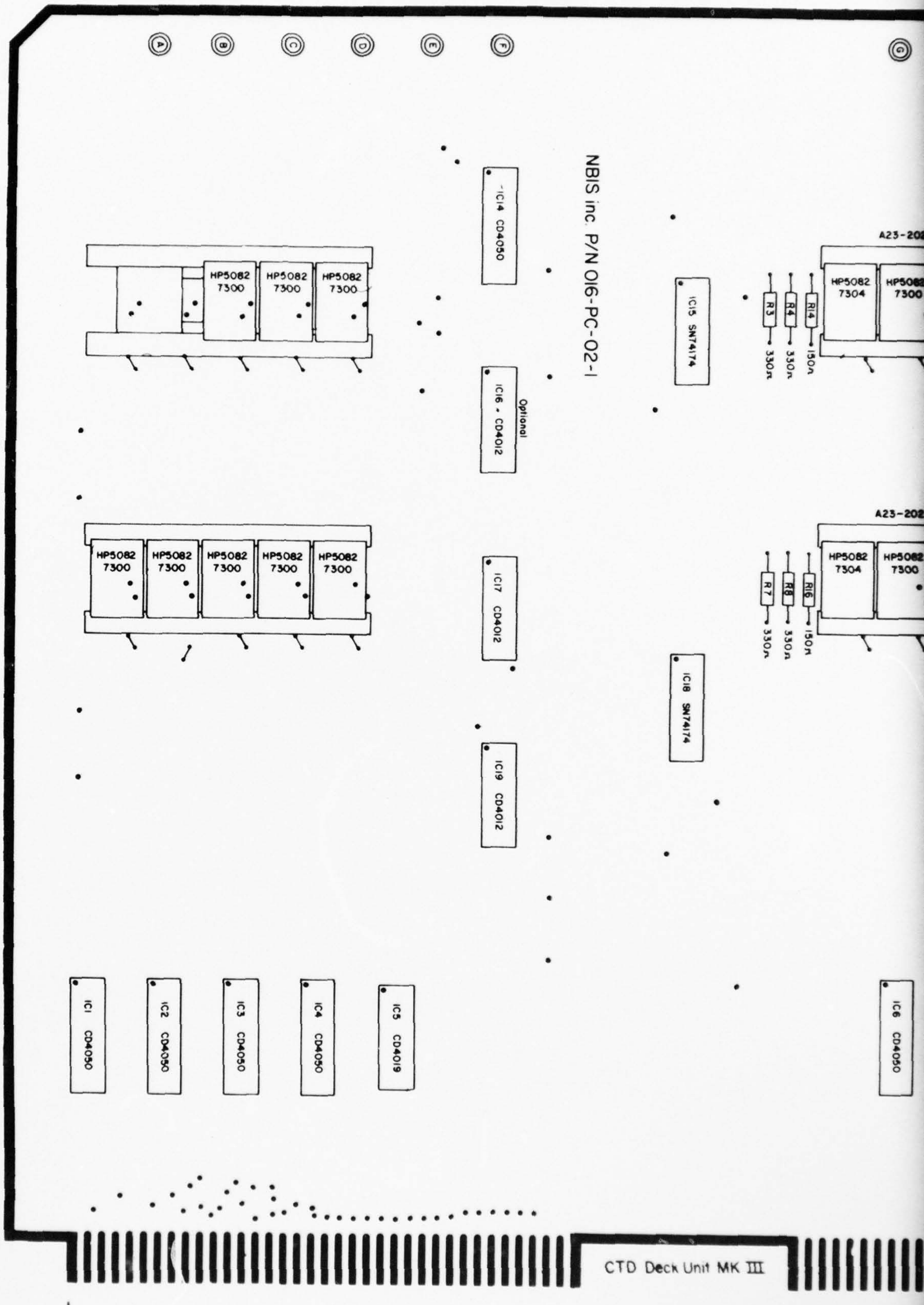


For display of data from computer nand gates should be set up as follows:

*Number converter board

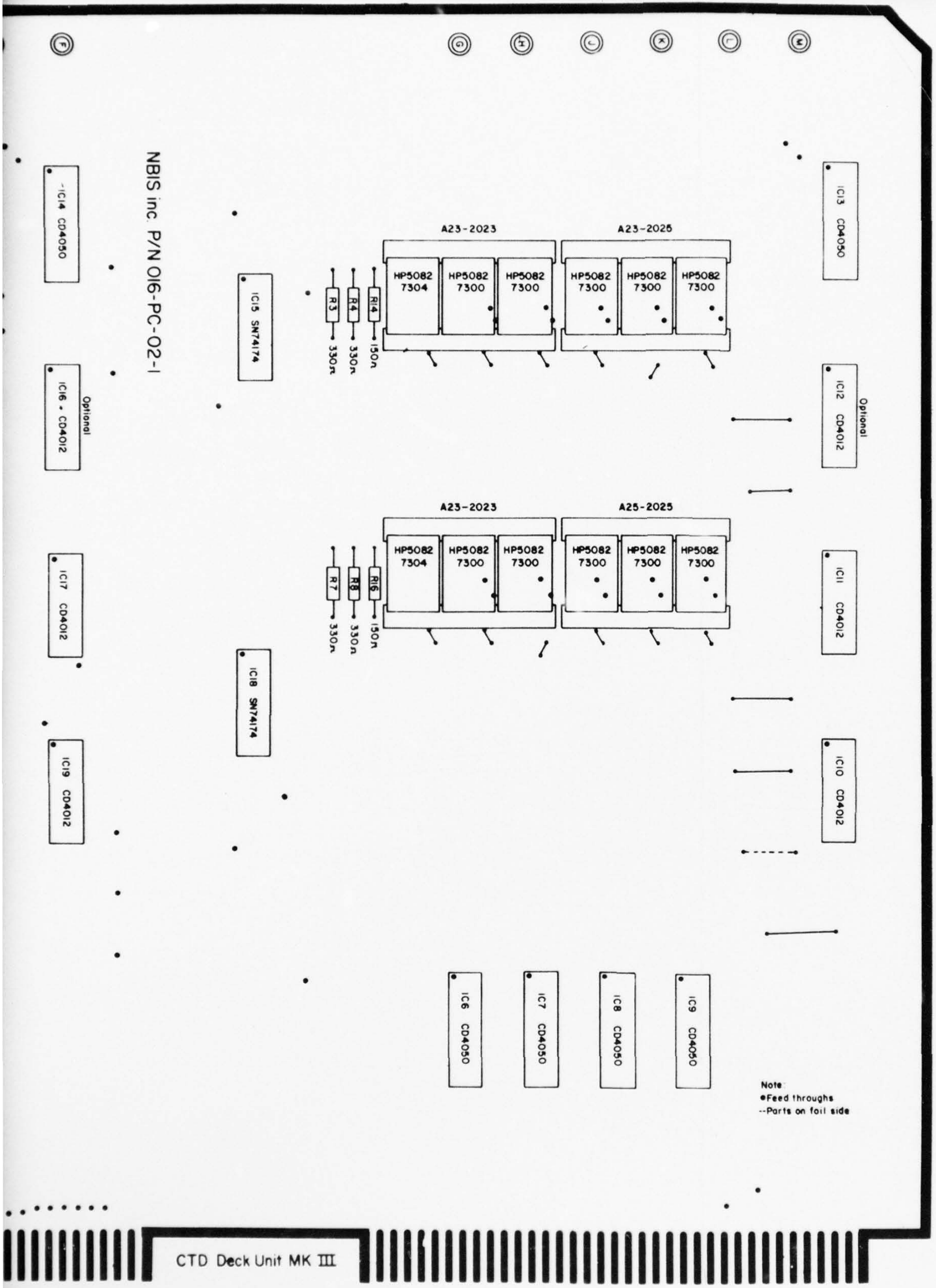
CTD DECK UNIT MK III

DISPLAY



NBIS inc. P/N 016-PC-02-I
A23-2021
A23-2023
HP5082 7300
HP5082 7304
IC14 CD4050
IC15 SN74174
IC16 - CD4012
Optional
IC17 CD4012
IC18 SN74174
IC19 CD4012
IC1 CD4050
IC2 CD4050
IC3 CD4050
IC4 CD4050
IC5 CD4019
IC6 CD4050
R3 330Ω
R4 330Ω
R14 150Ω
R7 330Ω
R8 330Ω
R16 150Ω
CTD Deck Unit MK III

Fig. 5.2.1(2)



DISPLAY

2

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12	Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp I/O (J11)	Internal I/O J12
1L	Common from Buss				2L,36L			1R	Sign Bit Input DisplayG						
2L	Common from Buss				1L,58L			2R	Sign Bit Input DisplayH	38R					
3L	+5V INPUT from Buss				4L,38L			3R	Sign Bit Input DisplayJ						
4L	+5V INPUT from Buss				3L			4R	Enable S_0,S_1,S_2 Input	51R			8R		
5L	+12V INPUT from Buss				6L			5R	Sign Bit Input DisplayK	26L					
6L	+12V INPUT from Buss				5L,40L			6R	Sign Bit Input DisplayM						
7L	BCD Input 10^4 (2)		47R					7R	Sign Bit Input DisplayL						
8L	BCD Input 10^4 (4)		46R					8R	Enable S_3,S_4,S_5Input				4R		
9L	BCD Input 10^3 (2)		51R					9R							
10L	BCD Input 10^3 (4)		50R					10R							
11L	BCD Input 10^2 (2)		55R					11R							
12L	BCD Input 10^2 (4)		54R					12R							
13L	BCD Input 10^1 (2)		59R					13R	Hundreds Count DisplayM				14R,26R		
14L	BCD Input 10^1 (4)		58R					14R	Tens Count Display M				13R,15R		
15L	BCD Input 10^0 (2)		63R					15R	Units Count Display M				14R,16R		
16L	BCD Input 10^0 (4)		62R					16R	Enable Display M				15R,17R		
17L	Hundreds Count H_1, IN	67L						17R	Hundreds Count DisplayL				16R,18R		
18L	Hundreds Count H_2, IN	68L						18R	Tens Count Display L				17R,19R		
19L	Hundreds Count H_3'' OUT							19R	Units Count Display L				18R,20R		
20L	C.T. Sample Hold Switch						AZ	20R	Enable Display L				19R,29R		
21L	Hundreds Count H_1'' OUT							21R	Enable Display K		39R				
22L	Tens Count Display F				23L,57L			22R	Units Count Display K	47L					
23L	Enable Display F				22L,25L			23R	Tens Count Display K	51L					
24L	Tens Count Display E				25L,59L			24R	Hundreds Count Display K				56L		
25L	Enable Display E				24L,23L			25R	Common				26R,60R		
26L	Units Count Display D	20L						26R	Common				25R,13R		
27L	Hundreds Count Display D				56L			27R	+5V INPUT				28R,63R		
28L	Tens Count Display C				29L,63L			28R	+5V INPUT				27R,		
29L	Enable Display C				28L,33L			29R	Hundreds Count DisplayJ				20R,30R		
30L	Tens Count Display B	52L						30R	Tens Count Display J				29R,31R		
31L	Enable Display B		36R					31R	Units Count Display J				30R,32R		
32L	Tens Count Display A				33L,67L			32R	Enable Display J				31R,66R		
33L	Enable Display A				32L,29L			33R	Hundreds Count DisplayH				56L		
34L								34R	Tens Count Display H	55L					
35L								35R							
36L	Common				37L,1L			36R							
37L	Common							37R							
38L	+5V Input				39L,3L			38R							
39L	+5V Input				38L			39R							
40L	+12V Input				41L			40R							
41L	+12V Input				40L,5L			41R							
42L								42R							
43L	BCD Input 10^4 (1)		44R					43R							
44L	BCD Input 10^4 (8)		45R					44R							
45L	BCD Input 10^3 (1)		48R					45R							
46L	BCD Input 10^3 (8)		49R					46R							

Fig. 5.2.1(3)

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Pin	Function			
22L	Tens Count Display F			23L,57L
23L	Enable Display F			22L,25L
24L	Tens Count Display E			25L,59L
25L	Enable Display E			24L,23L
26L	Units Count Display D	20L		
27L	Hundreds Count Display D			56L
28L	Tens Count Display C			29L,63L
29L	Enable Display C			28L,33L
30L	Tens Count Display B	52L		
31L	Enable Display B		36R	
32L	Tens Count Display A			33L,67L
33L	Enable Display A			32L,29L
34L				
35L				
36L	Common			37L,1L
37L	Common			
38L	+5V Input			39L,3L
39L	+5V Input			38L
40L	+12V Input			41L
41L	+12V Input			40L,5L
42L				
43L	BCD Input 10^4 (1)		44R	
44L	BCD Input 10^4 (8)		45R	
45L	BCD Input 10^3 (1)		48R	
46L	BCD Input 10^3 (8)		49R	
47L	BCD Input 10^2 (1)		52R	
48L	BCD Input 10^2 (8)		53R	
49L	BCD Input 10^1 (1)		56R	
50L	BCD Input 10^1 (8)		57R	
51L	BCD Input 10^0 (1)		60R	
52L	BCD Input 10^0 (8)		61R	
53L	Hundreds Count H_0, IN	66L		
54L	Hundreds Count H_3, IN	69L		
55L	Hundreds Count H_2'', OUT			
56L	Hundreds Count H_0'', OUT			27L,65L 33R,26R
57L	Hundreds Count Display F			58L,22L
58L	Units Count Display F			57L,2L
59L	Hundreds Count Display E			60L,24L
60L	Units Count Display E			59L,64L
61L	Enable Display D		40R	
62L	Tens Count Display D	56L		
63L	Hundreds Count Display C			64L,28L
64L	Units Count Display C			63L,60L
65L	Hundreds Count Display B			56L
66L	Units Count Display B	18L		
67L	Hundreds Count Display A			68L,32L
68L	Units Count Display A			67L
69L				
70L				
Connector: J 1				

Pin	Function			
22R	Units Count Display K	47L		
23R	Tens Count Display K	51L		
24R	Hundreds Count Display K		56L	
25R	Common		26R,60R	
26R	Common		25R,13R	
27R	+5V INPUT		28R,62R	
28R	+5V INPUT		27R,	
29R	Hundreds Count DisplayJ		20R,30R	
30R	Tens Count Display J		29R,31R	
31R	Units Count Display J		30R,32R	
32R	Enable Display J		31R,66R	
33R	Hundreds Count DisplayH		56L	
34R	Tens Count Display H	55L		
35R				
36R				
37R				
38R				
39R				
40R				
41R				
42R				
43R				
44R				
45R				
46R				
47R				
48R				
49R				
50R				
51R				
52R				
53R				
54R				
55R				
56R				
57R				
58R				
59R				
60R	Common		61R,25R	
61R	Common		60R	
62R	+5V INPUT		63R,27R	
63R	+5V INPUT		62R	
64R	Units Count Display H	19L		
65R	Enable Display H			CE
66R	Hundreds Count DisplayG		32R,67R	
67R	Tens Count Display G		66R,68R	
68R	Units Count Display G		67R,69R	
69R	Enable Display G			
70R				
Connector: J 2				

Name of Connector: DISPLAY BOARD

Part Number: P/N 016-PC-02-0

Date:

2

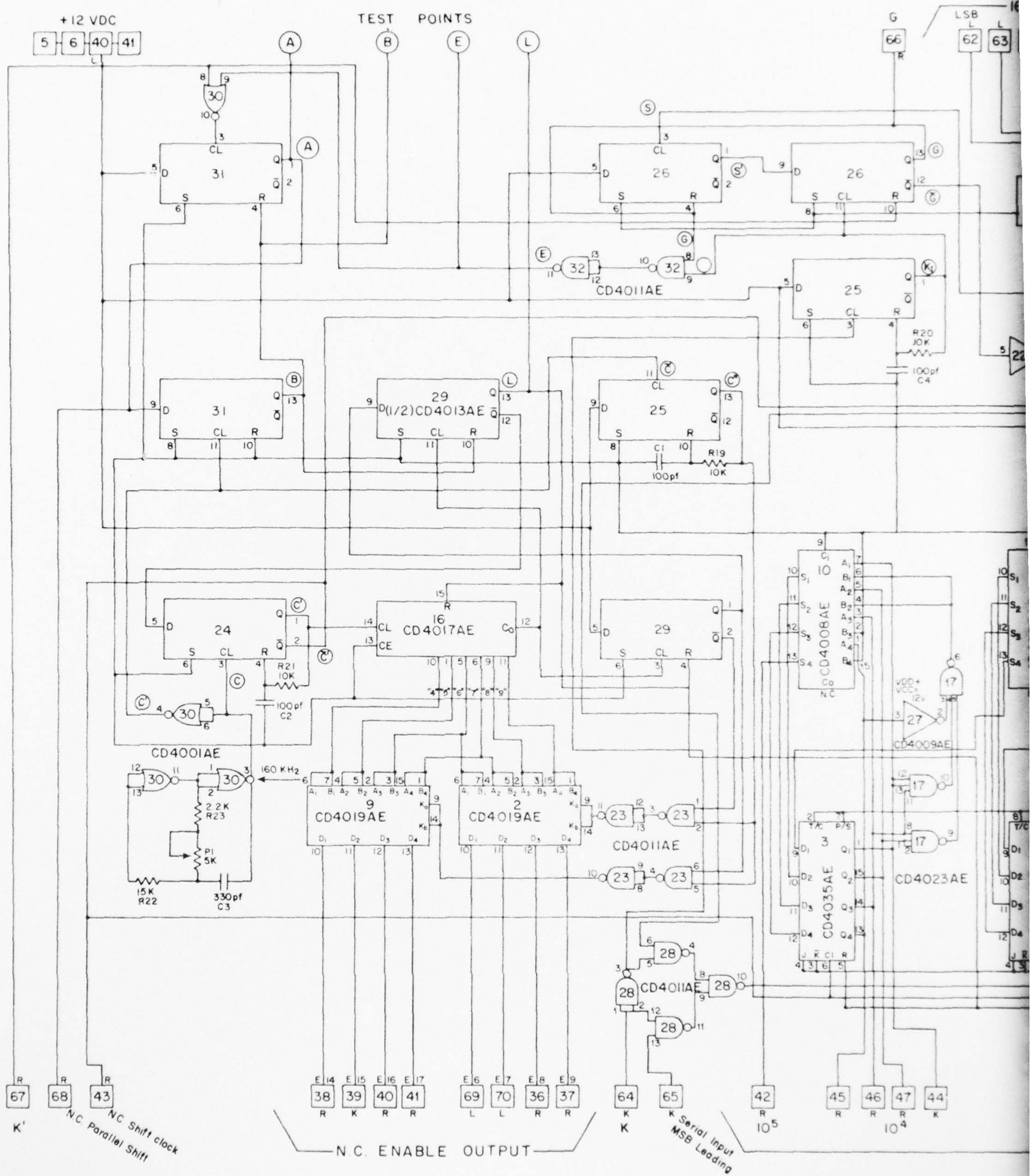
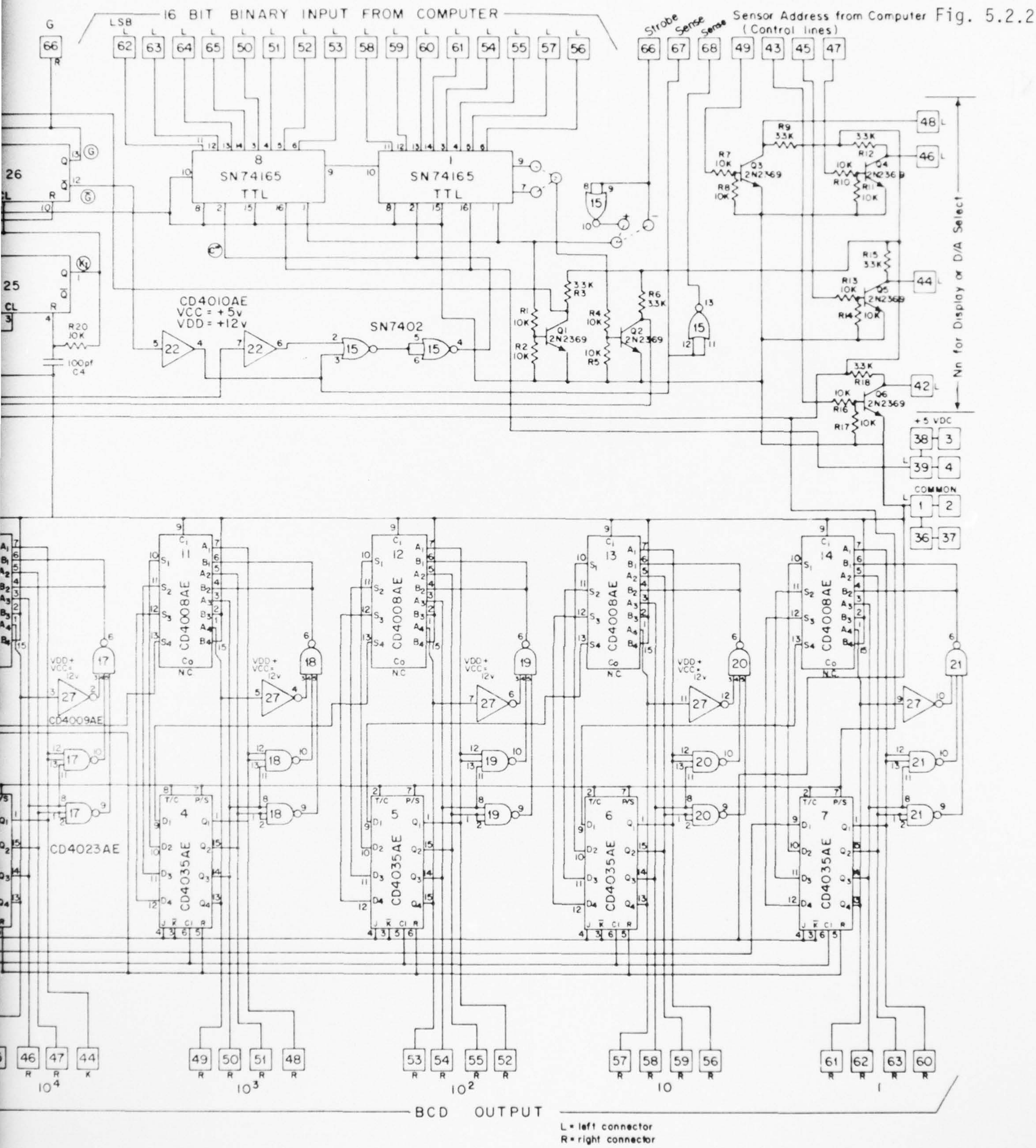

+12 VDC
TEST POINTS
LSB
CD4011AE
CD4013AE
CD4017AE
CD4001AE
160 KHz
CD4019AE
CD4008AE
CD4009AE
CD4035AE
CD4023AE
N.C. Shift clock
N.C. Parallel Shift
N.C. ENABLE OUTPUT
Serial Input MSB Leading
K'
K
10^5
10^4

Fig. 5.2.2



CTD DECK UNIT MK III
NUMBER CONVERTER

2

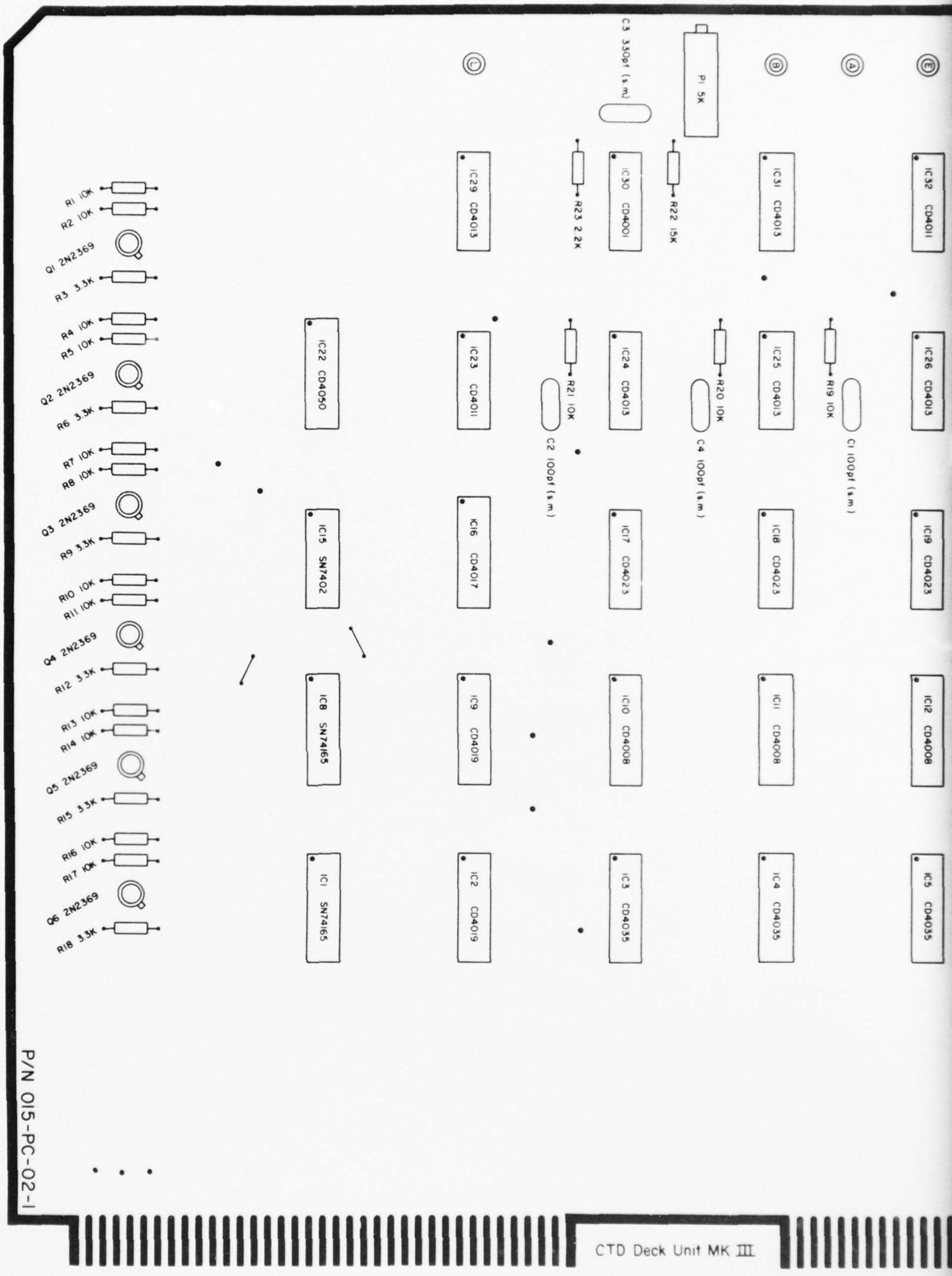
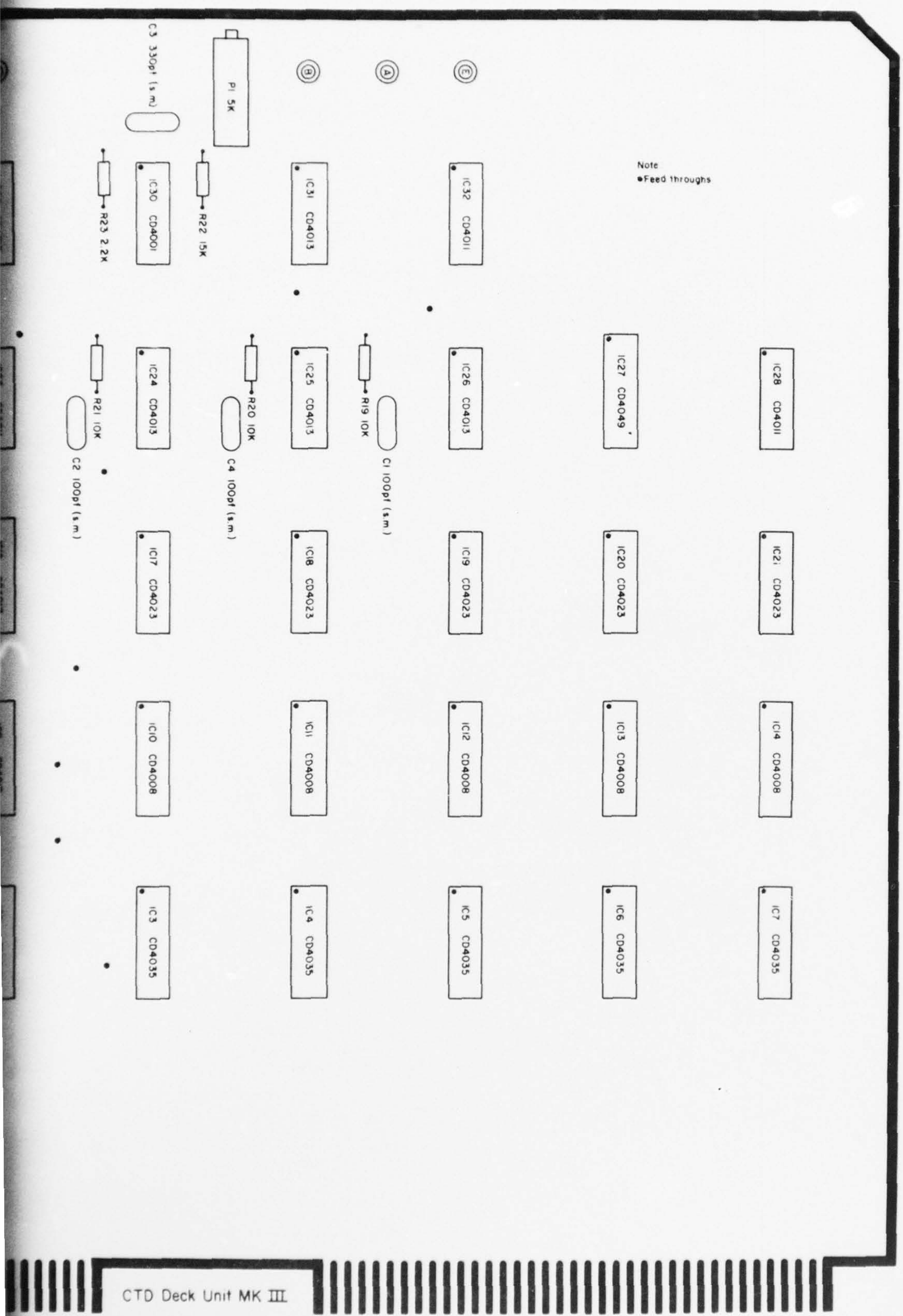

E
A
B
L
P1 5K
C3 330pf (s.m.)
IC32 CD4011
IC31 CD4013
IC30 CD4001
IC29 CD4013
R22 15K
R23 2.2K
IC26 CD4013
IC25 CD4013
IC24 CD4013
IC23 CD4011
IC22 CD4050
R19 10K
C1 100pf (s.m.)
R20 10K
C4 100pf (s.m.)
R21 10K
C2 100pf (s.m.)
IC19 CD4023
IC18 CD4023
IC17 CD4023
IC16 CD4017
IC15 SN7402
IC12 CD4008
IC11 CD4008
IC10 CD4008
IC9 CD4019
IC8 SN74165
IC5 CD4035
IC4 CD4035
IC3 CD4035
IC2 CD4019
IC1 SN74165
R1 10K
R2 10K
Q1 2N2369
R3 3.3K
R4 10K
R5 10K
Q2 2N2369
R6 3.3K
R7 10K
R8 10K
Q3 2N2369
R9 3.3K
R10 10K
R11 10K
Q4 2N2369
R12 3.3K
R13 10K
R14 10K
Q5 2N2369
R15 3.3K
R16 10K
R17 10K
Q6 2N2369
R18 3.3K
P/N 015-PC-02-1
CTD Deck Unit MK III

Fig. 5.2.2(2)



NUMBER CONVERTER

2

37L	Common to Buss	36L						37R	E9, Enable 9, OUT						
38L	+5V Input from Buss	3L,39L						38R	E14,Enable 14, OUT						BJ
39L	+5V Input from Buss	38L						39R	E15,Enable 15, OUT				21R		BL
40L	+12V Input from Buss	5L,41L						40R	E16,Enable 16, OUT				61L		BN
41L	+12V Input from Buss	40L						41R	E17,Enable 17, OUT						BR
42L	Sensor Add. 0 Output(CMOS)							42R	BCD Output 10^5 (1)						
43L	Sensor Add. 0 Input (TTL)					BJ		43R	N.C. Shift Clock OUT	40R					
44L	Sensor Add. 1 Output(CMOS)							44R	BCD Output 10^4 (1)				43L		
45L	Sensor Add. 1 Input (TTL)					BH		45R	BCD Output 10^4 (8)				44L		
46L	Sensor Add. 2 Output(CMOS)							46R	BCD Output 10^4 (4)				8L		
47L	Sensor Add. 2 Input (TTL)					BF		47R	BCD Output 10^4 (2)				7L		
48L	Sensor Add. 3 Output(CMOS)							48R	BCD Output 10^3 (1)			52L	45L		
49L	Sensor Add. 3 Input (TTL)					BK		49R	BCD Output 10^3 (8)			47L	46L		
50L	5th Bit // Input					CT		50R	BCD Output 10^3 (4)			45L	10L		
51L	6th Bit // Input					CR		51R	BCD Output 10^3 (2)			43L	9L		
52L	7th Bit // Input					CN		52R	BCD Output 10^2 (1)			42L	47L		
53L	8th Bit // Input					CL		53R	BCD Output 10^2 (8)			49L	48L		
54L	13th Bit // Input					BZ		54R	BCD Output 10^2 (4)			46L	12L		
55L	14th Bit // Input					BX		55R	BCD Output 10^2 (2)			44L	11L		
56L	16th MSB // Input					BT		56R	BCD Output 10^1 (1)			59L	49L		
57L	15th Bit // Input					BV		57R	BCD Output 10^1 (8)			62L	50L		
58L	9th Bit // Input					CJ		58R	BCD Output 10^1 (4)			61L	14L		
59L	10th Bit // Input					CF		59R	BCD Output 10^1 (2)			60L	13L		
60L	11th Bit // Input					CD		60R	BCD Output 10^0 (1)			64L	51L		
61L	12th Bit // Input					CB		61R	BCD Output 10^0 (8)			67L	52L		
62L	1st LSB // Input					DB		62R	BCD Output 10^0 (4)			66L	16L		
63L	2nd Bit // Input					CZ		63R	BCD Output 10^0 (2)			65L	15L		
64L	3rd Bit // Input					CX		64R	Serial Data Clk K IN	49L					
65L	4th Bit // Input					CV		65R	Serial Data In(MSB lead)	25L					
66L	STROBE IN					BN		66R	G						
67L	SENSE OUT					BL		67R	Serial Data Clock K^1 IN						
68L	SENSE OUT					BM		68R	N.C. Parallel SHIFT	39R					
69L	E6 Enable 6, OUT							69R							
70L	E7 Enable 7, OUT							70R							
Connector: J 3								Connector: J 4							

Name of Connector: NUMBER CONVERTER

Part Number: P/N 015-PC-02-0

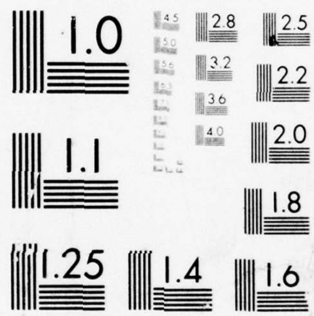
Date:

AD-A052 054 WOODS HOLE OCEANOGRAPHIC INSTITUTION MASS F/G 8/10
W.H.O.I./BROWN CONDUCTIVITY, TEMPERATURE, AND DEPTH MICROPROFIL--ETC(U)
FEB 78 N L BROWN, G K MORRISON N00014-66-C-0241
UNCLASSIFIED WHOI-78-23 NL

3 OF 3

AD
A052 054

END
DATE
FILMED
5-78
DDC

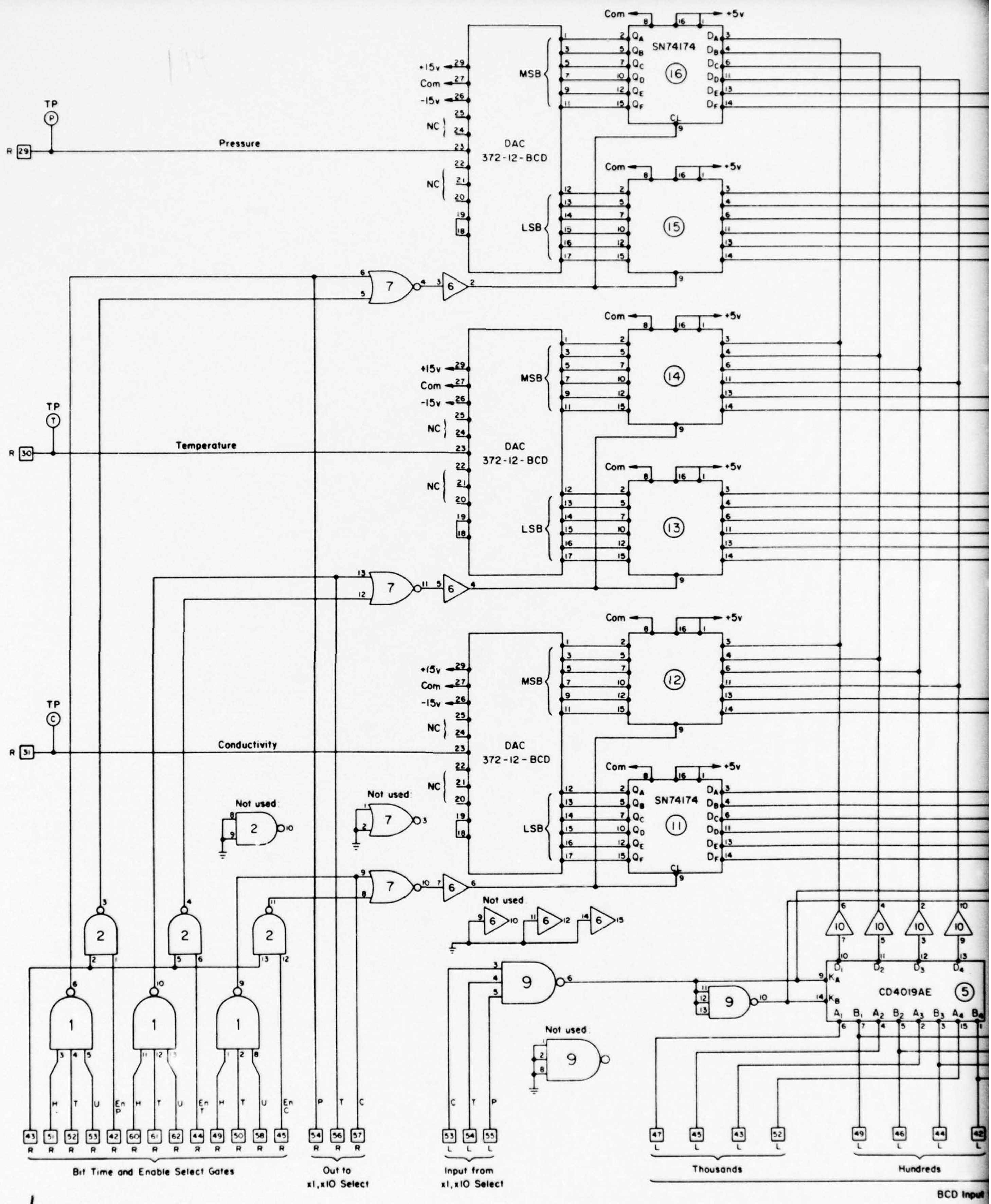


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Fig. 5.2.2(3)

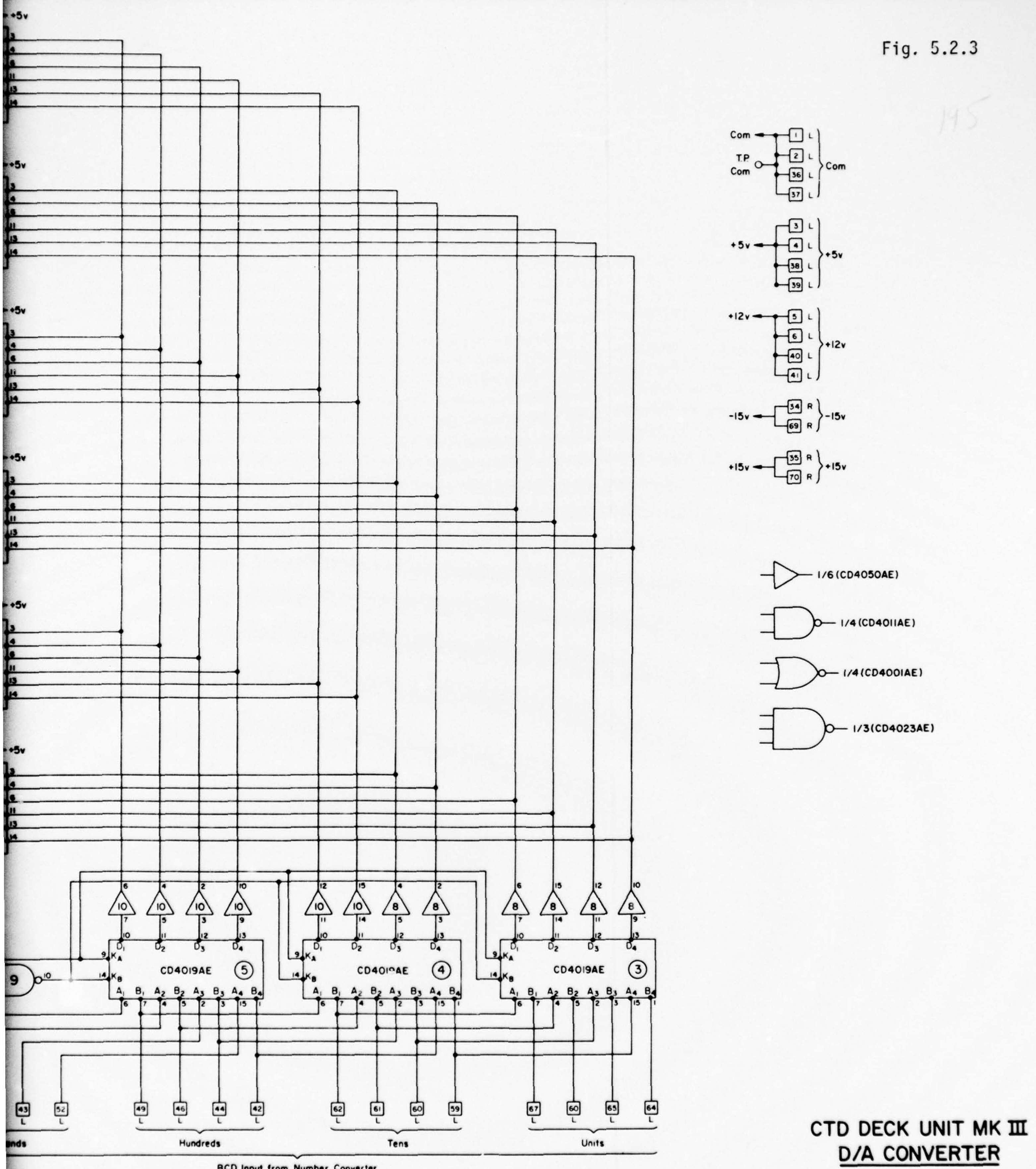
Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12	Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp I/O (J11)	Internal I/O J12
1L	Common to Buss	2L,36L						1R							
2L	Common to Buss	1L						2R							
3L	+5V Input from Buss	38L,4L						3R							
4L	+5V Input from Buss	3L						4R							
5L	+12V Input from Buss	40L,6L						5R							
6L	+12V Input from Buss	5L						6R							
7L								7R							
8L								8R							
9L								9R							
10L								10R							
11L								11R							
12L								12R							
13L								13R							
14L								14R							
15L								15R							
16L								16R							
17L								17R							
18L								18R							
19L								19R							
20L								20R							
21L								21R							
22L								22R							
23L								23R							
24L								24R							
25L								25R							
26L								26R							
27L								27R							
28L								28R							
29L								29R							
30L								30R							
31L								31R							
32L								32R							
33L								33R							
34L								34R							
35L								35R							
36L	Common to Buss	1L,37L						36R	E8, Enable 8, OUT				31L		
37L	Common to Buss	36L						37R	E9, Enable 9, OUT						
38L	+5V Input from Buss	3L,39L						38R	E14, Enable 14, OUT						BJ
39L	+5V Input from Buss	38L						39R	E15, Enable 15, OUT				21R		BL
40L	+12V Input from Buss	5L,41L						40R	E16, Enable 16, OUT				61L		BN
41L	+12V Input from Buss	40L						41R	E17, Enable 17, OUT						BR
42L	Sensor Add. 0 Output (CMOS)							42R	BCD Output 10^5 (1)						
43L	Sensor Add. 0 Input (TTL)					BJ		43R	N.C. Shift Clock OUT	40R					
44L	Sensor Add. 1 Output (CMOS)							44R	BCD Output 10^4 (1)				43L		
45L	Sensor Add. 1 Input (TTL)					BH		45R	BCD Output 10^4 (8)				44L		
46L	Sensor Add. 2 Output (CMOS)							46R	BCD Output 10^4 (4)				8L		
47L	Sensor Add. 2 Input (TTL)					BF		47R	BCD Output 10^4 (2)				7L		
48L	Sensor Add. 3 Output (CMOS)							48R	BCD Output 10^3 (1)			52L	45L		
49L	Sensor Add. 3 Input (TTL)					BK		49R	BCD Output 10^3 (8)			47L	46L		
50L	5th Bit // Input					CT		50R	BCD Output 10^3 (4)			45L	10L		
51L	6th Bit // Input					CR		51R	BCD Output 10^3 (2)			43L	9L		
52L	7th Bit // Input					CN		52R	BCD Output 10^2 (1)			42L	47L		
53L	**8th Bit // Input**					CL		53R	**BCD Output 10^2 (8)**			49L	48L		

2



Pressure
Temperature
Conductivity
DAC
372-12-BCD
SN74174
MSB
LSB
NC
Com
+5v
+15v
-15v
TP
Not used
CD4019AE
Bit Time and Enable Select Gates
Out to
x1, x10 Select
Input from
x1, x10 Select
Thousands
Hundreds
BCD Input

Fig. 5.2.3



CTD DECK UNIT MK III
D/A CONVERTER

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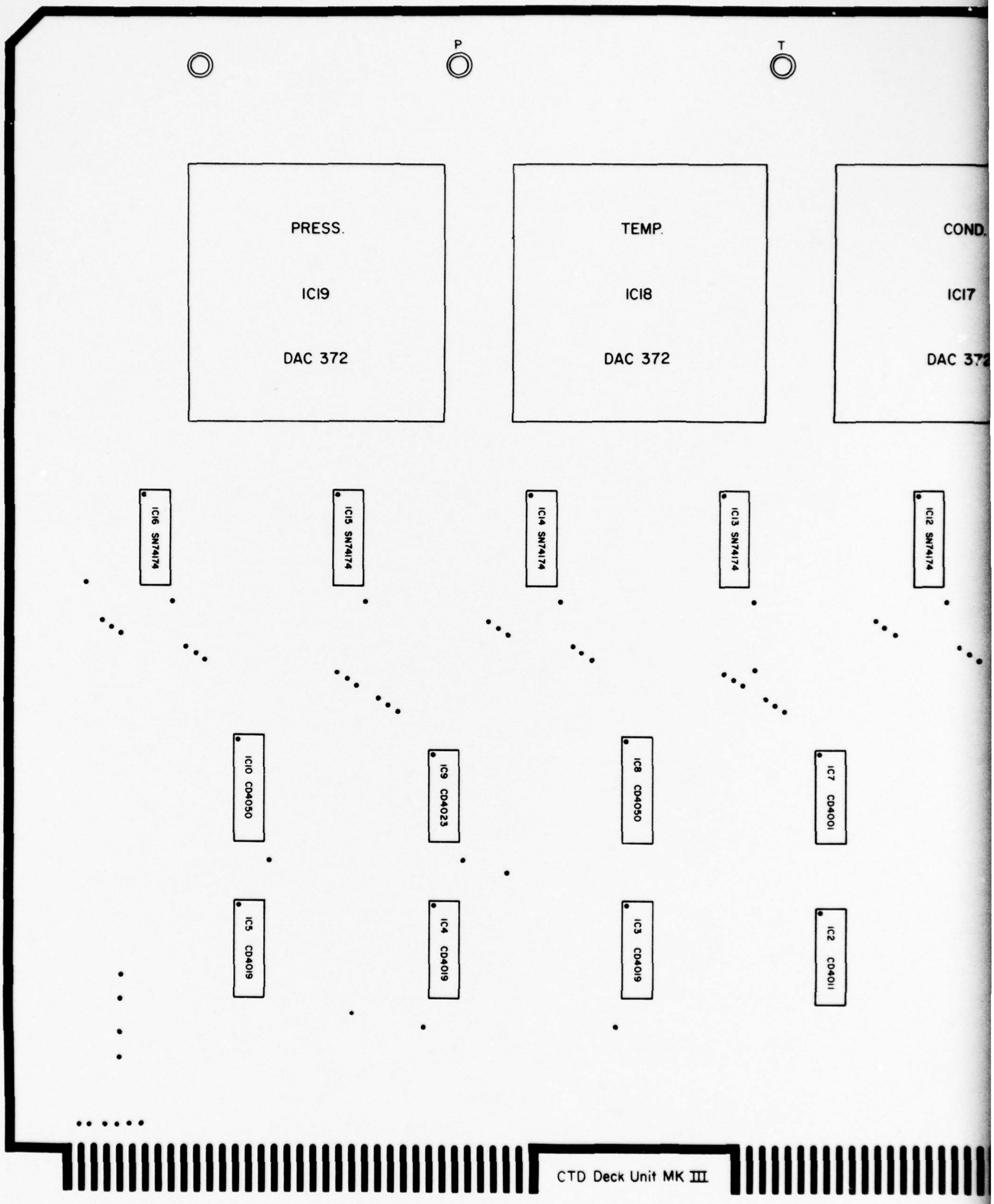
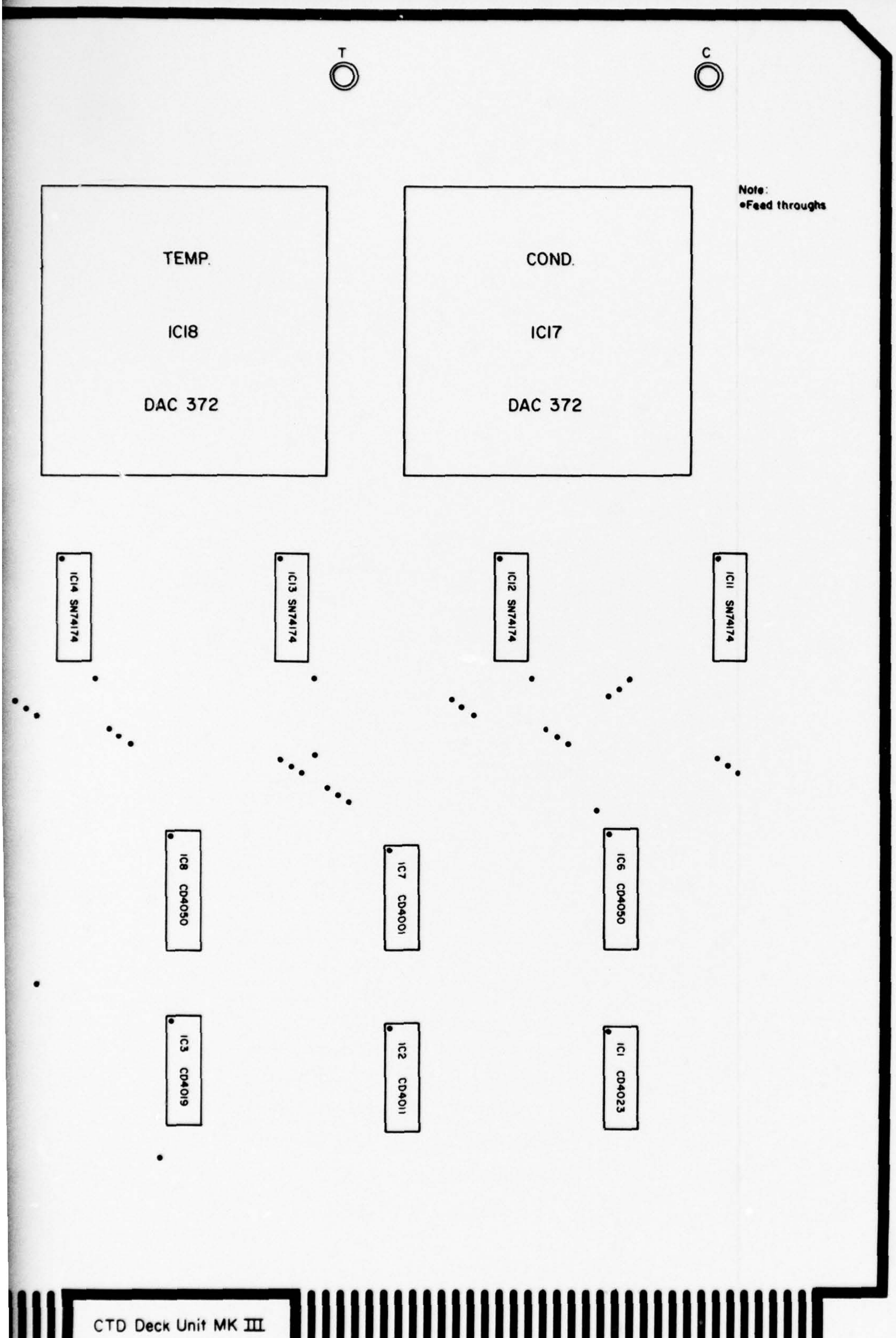


P
T
PRESS.
IC19
DAC 372
TEMP.
IC18
DAC 372
COND.
IC17
IC16 SN74174
IC15 SN74174
IC14 SN74174
IC13 SN74174
IC12 SN74174
IC10 CD4050
IC9 CD4023
IC8 CD4050
IC7 CD4001
IC5 CD4019
IC4 CD4019
IC3 CD4019
IC2 CD4011
CTD Deck Unit MK III

Fig. 5.2.3(2)



D/A CONVERTER

2

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12	Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp I/O (J11)	Internal I/O J12
1L	Common from Buss			2L, 36L				1R							
2L	Common from Buss			1L			AY, BA	2R							
3L	+5V Input from Buss			38L, 4L				3R							
4L	+5V Input from Buss			3L				4R							
5L	+12V Input from Buss			40L, 6L				5R							
6L	+12V Input from Buss			5L				6R							
7L								7R							
8L								8R							
9L								9R							
10L								10R							
11L								11R							
12L								12R							
13L								13R							
14L								14R							
15L								15R							
16L								16R							
17L								17R							
18L								18R							
19L								19R							
20L								20R							
21L								21R							
22L								22R							
23L								23R							
24L								24R							
25L								25R							
26L								26R							
27L								27R							
28L								28R							
29L								29R	Press D/A Output						AV
30L								30R	Temp D/A Output						AW
31L								31R	Cond D/A Output						AZ
32L								32R							
33L								33R							
34L								34R	-15V Input from Buss			69R			
35L								35R	+15V Input from Buss			70R			
36L	Common from Buss			1L, 37L				36R							
37L	Common from Buss			36L			BB	37R							
38L	+5V Input from Buss			3L, 39L				38R							
39L	+5V Input from Buss			38L				39R							
40L	+12V Input from Buss			5L, 41L				40R							
41L	+12V Input from Buss			40L				41R							
42L	**BCD Input 10^2 (1)**		52R					**42R**	**Enable Press.**						CF

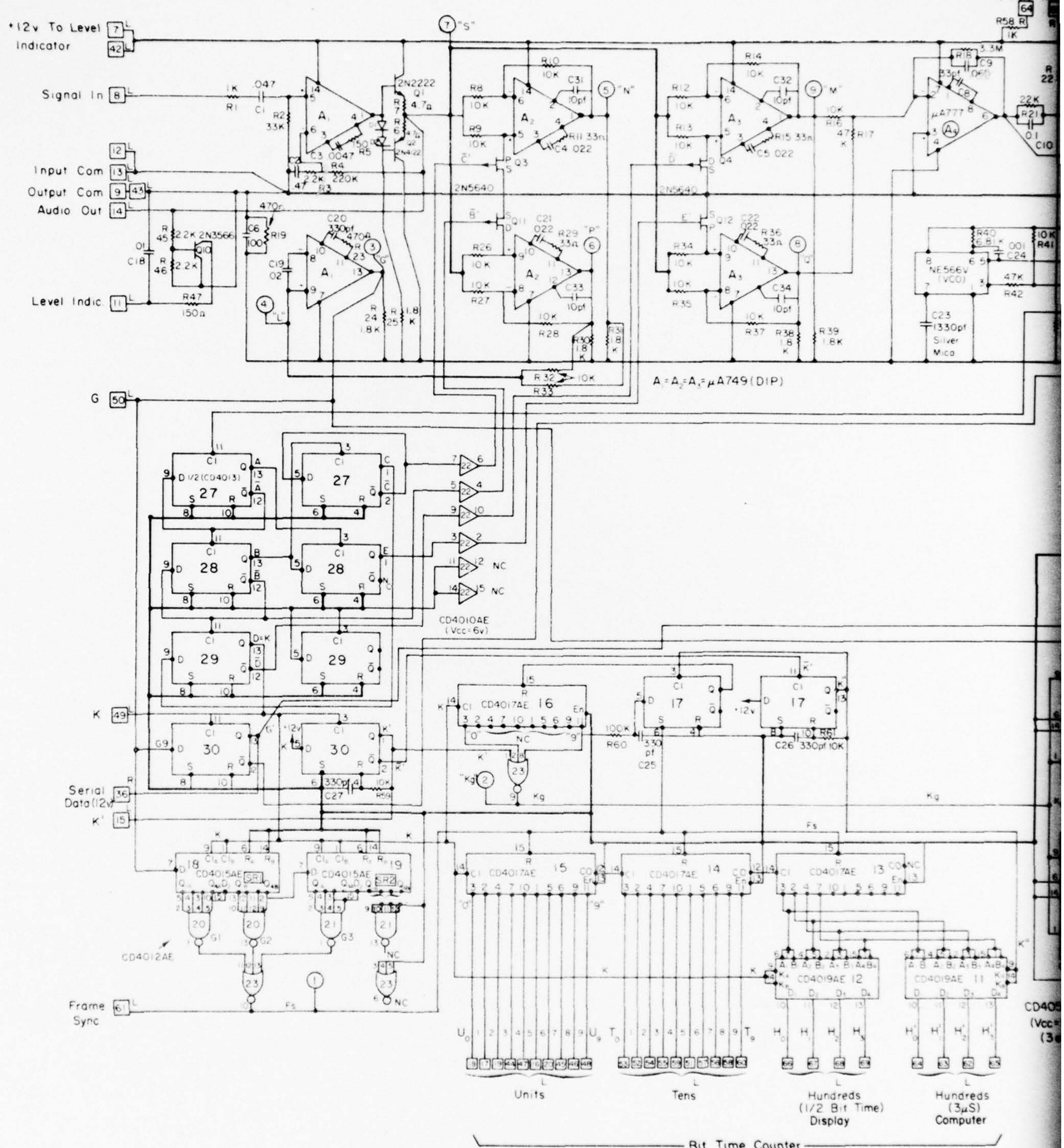
Fig. 5.2.3(3)

19L							
20L							
21L							
22L							
23L							
24L							
25L							
26L							
27L							
28L							
29L							
30L							
31L							
32L							
33L							
34L							
35L							
36L	Common from Buss			1L,37L			
37L	Common from Buss			36L			BB
38L	+5V Input from Buss			3L,39L			
39L	+5V Input from Buss			38L			
40L	+12V Input from Buss			5L,41L			
41L	+12V Input from Buss			40L			
42L	BCD Input 10^2 (1)		52R				
43L	BCD Input 10^3 (2)		51R				
44L	BCD Input 10^2 (2)		55R				
45L	BCD Input 10^3 (4)		50R				
46L	BCD Input 10^2 (4)		54R				
47L	BCD Input 10^3 (8)		49R				
48L							
49L	BCD Input 10^2 (8)		53R				
50L							
51L							
52L	BCD Input 10^3 (1)		48R				
53L	X1,X10Cond.D/A Switch						AP
54L	X1,X10Temp.D/A Switch						AS
55L	X1,X10Press.D/A Switch						AU
56L							
57L							
58L							
59L	BCD Input 10^1 (1)		56R				
60L	BCD Input 10^1 (2)		59R				
61L	BCD Input 10^1 (4)		58R				
62L	BCD Input 10^1 (8)		57R				
63L							
64L	BCD Input 10^0 (1)		60R				
65L	BCD Input 10^0 (2)		63R				
66L	BCD Input 10^0 (4)		62R				
67L	BCD Input 10^0 (8)		61R				
68L							
69L							
70L							
Connector: J5							

19R							
20R							
21R							
22R							
23R							
24R							
25R							
26R							
27R							
28R							
29R	Press D/A Output						AV
30R	Temp D/A Output						AW
31R	Cond D/A Output						AZ
32R							
33R							
34R	-15V Input from Buss			69R			
35R	+15V Input from Buss			70R			
36R							
37R							
38R							
39R							
40R							
41R							
42R	Enable Press.						CF
43R	Sample Hold Sw., C.T.						AM
44R	Enable Temp						CJ
45R	Enable Cond.						CL
46R							
47R							
48R							
49R	Hundreds Count, Cond.	66L					
50R	Tens Count, Cond.	56L					
51R	Hundreds Count, Press.	66L					
52R	Tens Count, Press.	55L					
53R	Units Count, Press.	19L					
54R	X10 out PressD/A Switch						BE
55R							
56R	X10 out TempD/A Switch						BF
57R	X10 out CondD/A Switch						BH
58R	Units Count, Cond	20L					
59R	Hundreds Count, Temp	66L					
60R	Tens Count, Temp	51L					
61R	Units Count Temp	47L					
62R							
63R							
64R							
65R							
66R							
67R							
68R							
69R	-15V Input from Buss			34R			
70R	+15V Input from Buss			35R			
Connector: J6							

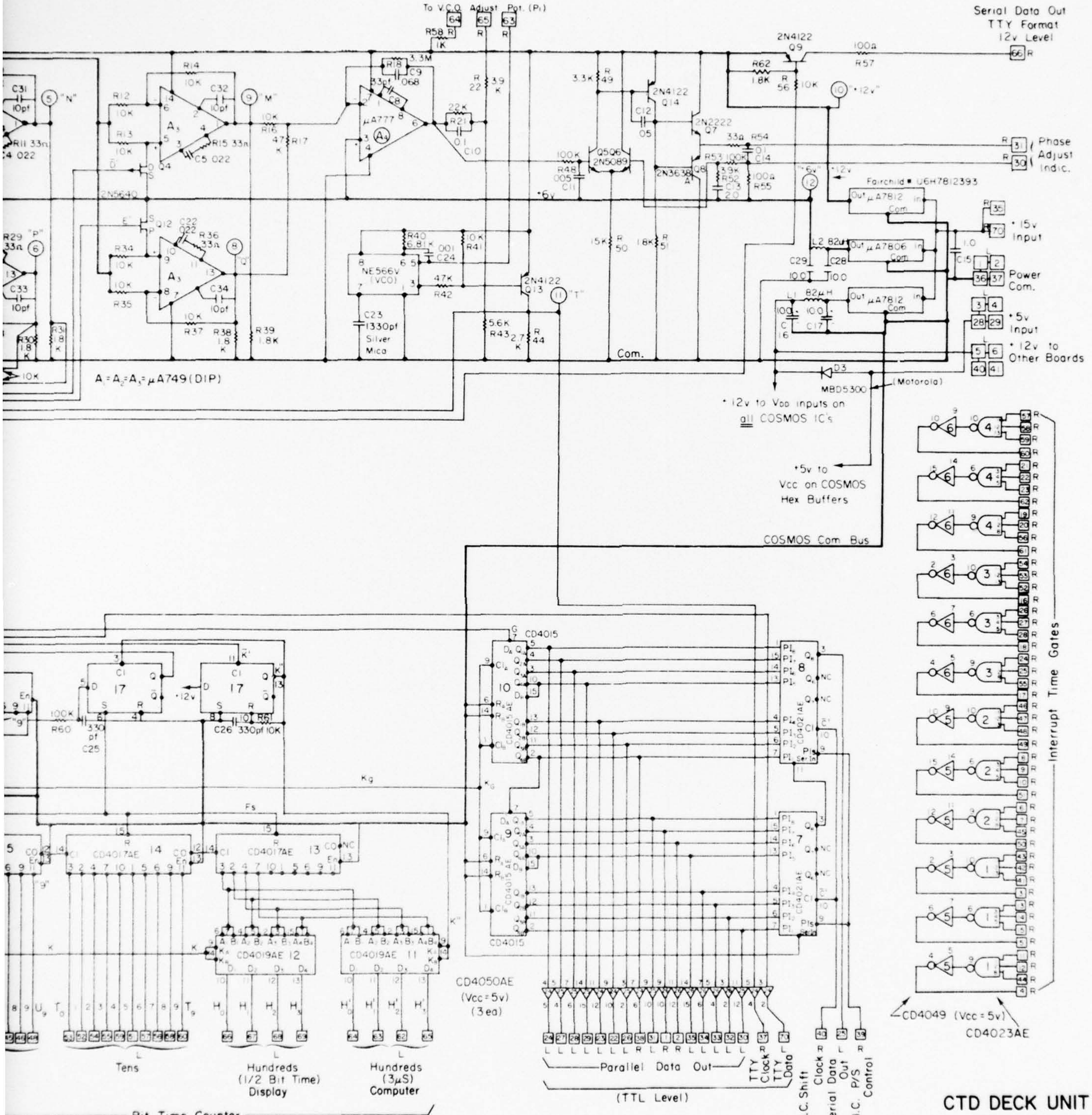
Name of Connector: D/A CONVERTER   Part Number: P/N O/T-PC-02-0   Date:

2


+12v To Level Indicator
Signal In
Input Com
Output Com
Audio Out
Level Indic.
G
K
Serial Data (12v)
K'
Frame Sync
To V.C.O.
2N2222
2N5640
2N3566
μA777
NE566V (VCO)
C23 1330pf Silver Mica
A1=A2=A3=μA749 (DIP)
D 1/2 (CD4013)
CD4010AE (Vcc=6v)
CD4017AE
CD4015AE
CD4012AE
CD4019AE
Units
Tens
Hundreds (1/2 Bit Time) Display
Hundreds (3μS) Computer
Bit Time Counter

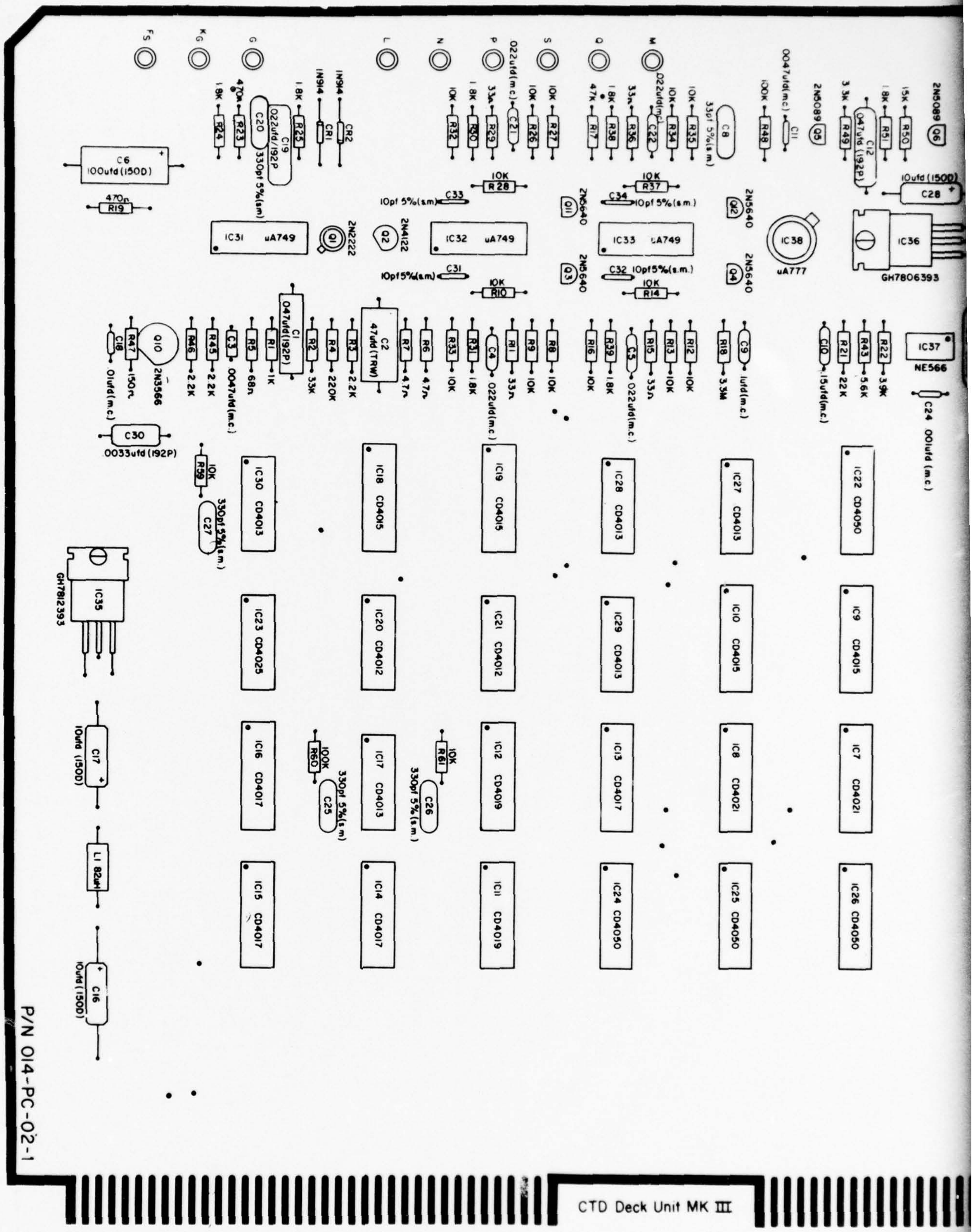
1

Fig. 5.2.4



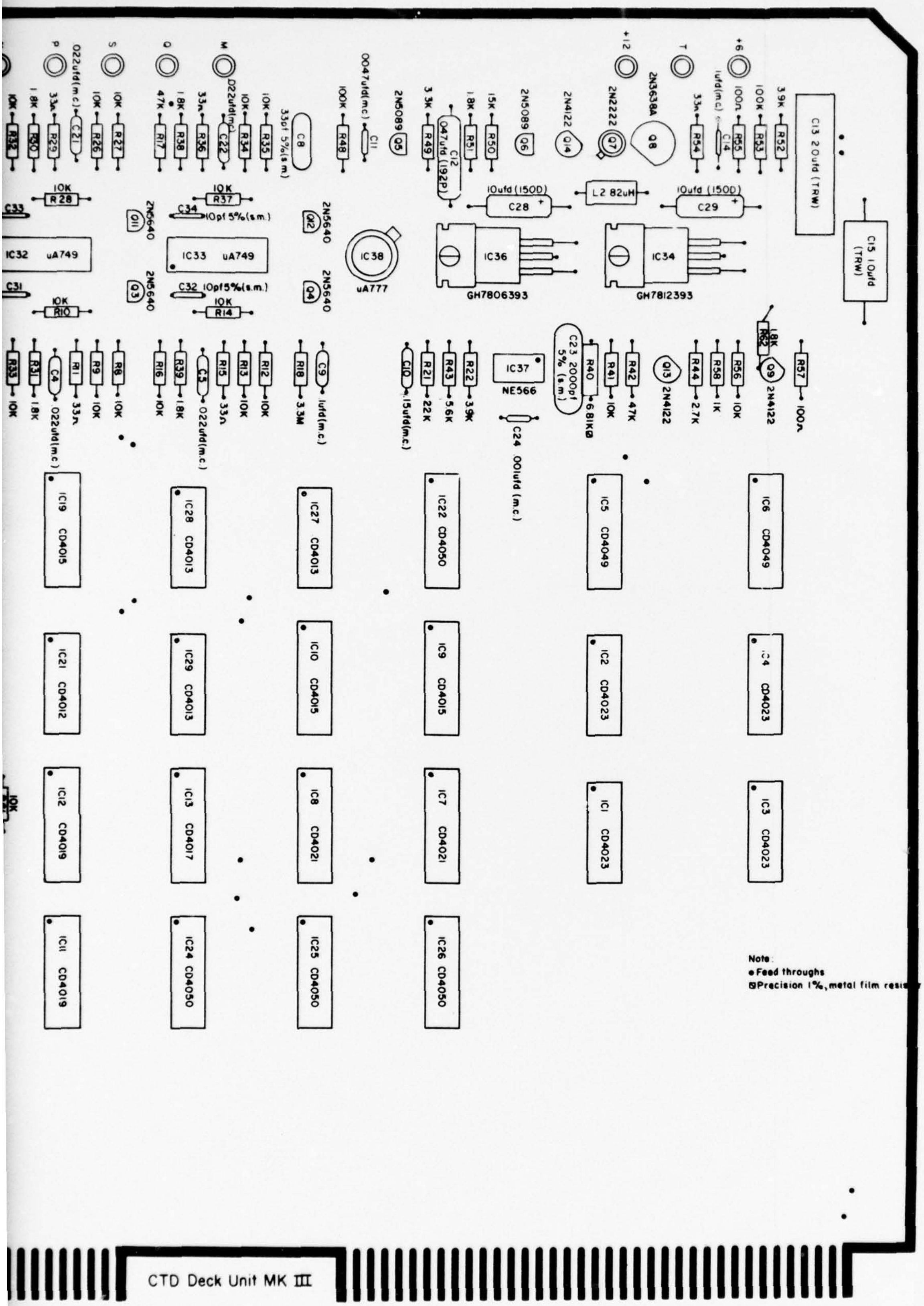
CTD DECK UNIT MK III
DEMODULATOR

2



CTD Deck Unit MK III
P/N 014-PC-02-1
IC31 uA749
IC32 uA749
IC33 uA749
IC38 uA777
IC36 GH7806393
IC35 GH7812393
IC37 NE566
IC30 CD4013
IC18 CD4015
IC19 CD4015
IC28 CD4013
IC27 CD4013
IC22 CD4050
IC23 CD4025
IC20 CD4012
IC21 CD4012
IC29 CD4013
IC10 CD4015
IC9 CD4015
IC16 CD4017
IC17 CD4013
IC12 CD4019
IC13 CD4017
IC8 CD4021
IC7 CD4021
IC15 CD4017
IC14 CD4017
IC11 CD4019
IC24 CD4050
IC25 CD4050
IC26 CD4050
C6 100ufd (150D)
C28 10ufd (150D)
C17 10ufd (150D)
C16 10ufd (150D)
L1 82uH
C30 0033ufd (192P)

Fig. 5.2.4(2)



DEMODULATOR

2

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12	Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12
1L	Common to Buss	2L,36L						1R	7th Bit // OUT					W	
2L	Common to Buss	1L						2R	6th Bit // OUT					Y	
3L	+5V Input from Buss	38L,4L						3R	Temperature Interrupt					AS	
4L	+5V Input from Buss	3L						4R	Frame Sync Interrupt					AM	
5L	+12V Output to Buss	40L,6L						5R	Pressure Interrupt					AP	
6L	+12V Output to Buss	5L						6R	Units Count 6, Cond.	20L					
7L	Level Indicator, Anode	42L					A	7R	Tens Count 7, Cond.	56L					
8L	Signal Input						R	8R	Units Count 7, Sign Bits	45L					
9L	OUTPUT COMMON	43L					D	9R	Tens Count 8, Sign Bits	58L					
10L	- N/C -							10R	Hund Count Ho[1] Sign Bits	15R					
11L	Level Indicator Cathode						B	11R	Units Count 0, F.S.	18L					
12L	Input Common #II						F	12R	Tens Count 1, F.S.	52L					
13L	Input Common # I						H	13R	Units Count 2, Pressure	19L					
14L	Audio Out						W	14R	Tens Count 3, Pressure	55L					
15L	Serial Data Clock K[1]		67R[1]					15R	Hund Count Ho[1] Pressure	10R,41R					
16L	Bit Time Count Units 5							16R	Spare Interrupt					BB	
17L	Bit Time Count Units 1							17R	Spare Interrupt					AZ	
18L	Bit Time Count Units 0	11R						18R	Spare Interrupt					BA	
19L	Bit Time Count Units 2	13R						19R							
20L	Bit Time Count Units 6	6R						20R							
21L								21R							
22L	11th Bit // OUT					M		22R							
23L	12th Bit // OUT					K		23R							
24L	16th MSB // OUT					A		24R							
25L	Serial Data Out (MSB lead)		65R					25R							
26L	10th Bit // OUT				5R	P		26R							
27L	15th Bit // OUT					C		27R							
28L	14th Bit // OUT					E		28R							
29L	13th Bit // OUT					H		29R	-N/C-						
30L	1st L.S.B. // OUT					AK		30R	Phase Adj LED						AE
31L	8th Bit // OUT					U		31R	Phase Adj LED						AF
32L	2nd Bit // OUT					AH		32R	-N/C-						
33L	3rd Bit // OUT					AE		33R	-N/C-						
34L	4th Bit // OUT					AC		34R	-N/C-						
35L	5th Bit // OUT					AA		35R	+15V Input from Buss	70R					
36L	Common to Buss	1L,37L						36R	Serial Data Out (12V)						
37L	Common to Buss	36L,48R						37R	TTY Clock Out 5V Level						T
38L	+5V Input from Buss	3L,39L						38R	9th Bit // OUT				2R	S	
39L	+5V Input from Buss	38L						39R	Number Conv P/S Control		68R				
40L	+12V Output to Buss	5L,41L						40R	Number Conv. Shift Clock		43R				
41L	+12V Output to Buss	40L						41R	Hund Count Ho[1], Temp	15R,44R					
42L	Level Indicator Anode	7L						42R	Tens Count 5, Temp	51L					
43L	Output Common	9L						43R	Units Count 4, Temp	47L					

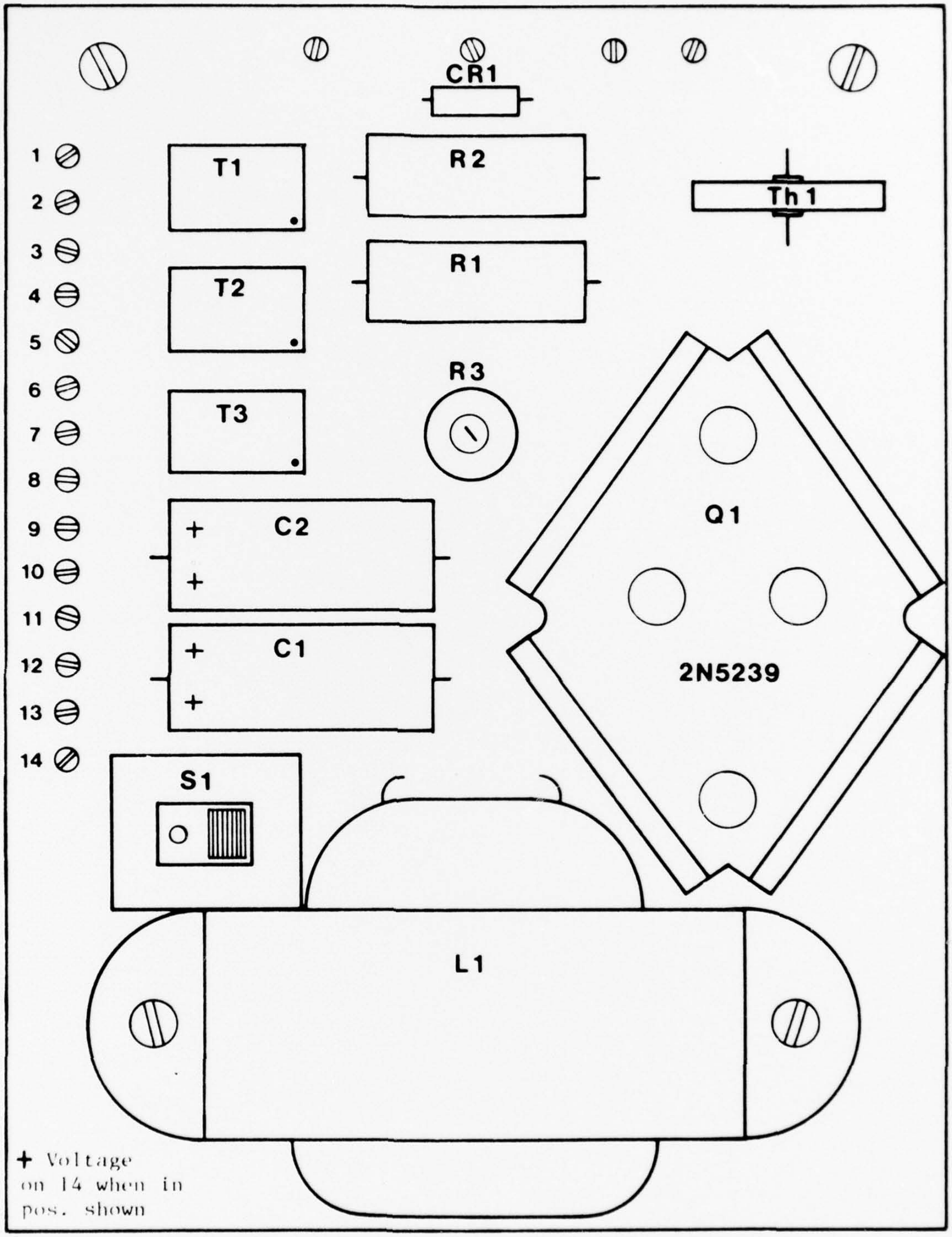
18L	Bit Time Count Units 0	11R						18R	Spare Interrupt					BA	
19L	Bit Time Count Units 2	13R						19R							
20L	Bit Time Count Units 6	6R						20R							
21L								21R							
22L	11th Bit // OUT					M		22R							
23L	12th Bit // OUT					K		23R							
24L	16th MSB // OUT					A		24R							
25L	Serial Data Out (MSB lead)		65R					25R							
26L	10th Bit // OUT				5R	P		26R							
27L	15th Bit // OUT					C		27R							
28L	14th Bit // OUT					E		28R							
29L	13th Bit // OUT					H		29R	-N/C-						
30L	1st L.S.B. // OUT					AK		30R	Phase Adj LED						AE
31L	8th Bit // OUT					U		31R	Phase Adj LED						AF
32L	2nd Bit // OUT					AH		32R	-N/C-						
33L	3rd Bit // OUT					AE		33R	-N/C-						
34L	4th Bit // OUT					AC		34R	-N/C-						
35L	5th Bit // OUT					AA		35R	+15V Input from Buss	70R					
36L	Common to Buss	1L,37L						36R	Serial Data Out (12V)						
37L	Common to Buss	36L,48R						37R	TTY Clock Out 5V Level						T
38L	+5V Input from Buss	3L,39L						38R	9th Bit // OUT				2R	S	
39L	+5V Input from Buss	38L						39R	Number Conv P/S Control		68R				
40L	+12V Output to Buss	5L,41L						40R	Number Conv. Shift Clock		43R				
41L	+12V Output to Buss	40L						41R	Hund Count Ho', Temp	15R,44R					
42L	Level Indicator Anode	7L						42R	Tens Count 5, Temp	51L					
43L	Output Common	9L						43R	Units Count 4, Temp	47L					
44L	Bit Time Count Units 3							44R	Hund Count Ho, F.S.	41R,45R					
45L	Bit Time Count Units 7	8R						45R	Hund Count Ho, Cond.	44R,64L					
46L	Bit Time Count Units 8							46R	Spare Int. Time Gate In	47R					
47L	Bit Time Count Units 4	43R						47R	Spare Int. Time Gate In	46R,48R					
48L	Bit Time Count Units 9							48R	Spare Int. Time Gate In	47R,37L					
49L	Serial Data Clock K		64R					49R	Spare Interrupt					AY	
50L	Test Point G							50R	Conductivity Interrupt					AU	
51L	Bit Time Count Tens 5	42R						51R	Sign Bits Interrupt				4R	AW	
52L	Bit Time Count Tens 1	12R						52R							
53L	Bit Time Count Tens 0							53R							
54L	Bit Time Count Tens 2							54R							
55L	Bit Time Count Tens 3	14R						55R							
56L	Bit Time Count Tens 7	7R						56R							
57L	Bit Time Count Tens 6							57R							
58L	Bit Time Count Tens 8	9R						58R							
59L	Bit Time Count Tens 4							59R							
60L	Bit Time Count Tens 9							60R	Spare Interrupt					BE	
61L	Frame Sync						N	61R	Spare Interrupt					BC	
62L	Bit Time Count $H_{\frac{1}{2}}$							62R	Spare Interrupt					BD	
63L	Bit Time Count $H_{\frac{1}{1}}$ 3µSec							63R	Phase Adj Pot, Center tap						AJ
64L	Bit Time Count $H_{\frac{1}{0}}$	45R						64R	Phase Adj Pot, CCW End						AK
65L	Bit Time Count $H_{\frac{1}{3}}$							65R	Phase Adj Pot, CW End						AL
66L	Bit Time Count H_0							66R	Serial Data Out, 12V Level						BC
67L	Bit Time Count H_1 (½ Bit							67R	-N/C-						
68L	Bit Time Count H_2 Time)							68R	-N/C-						
69L	Bit Time Count H_3							69R	-N/C-						
70L	Serial Data Out TTY 5V						L	70R	+15V Input from Buss	35R					
Connector: J 7								Connector: J 8							

2

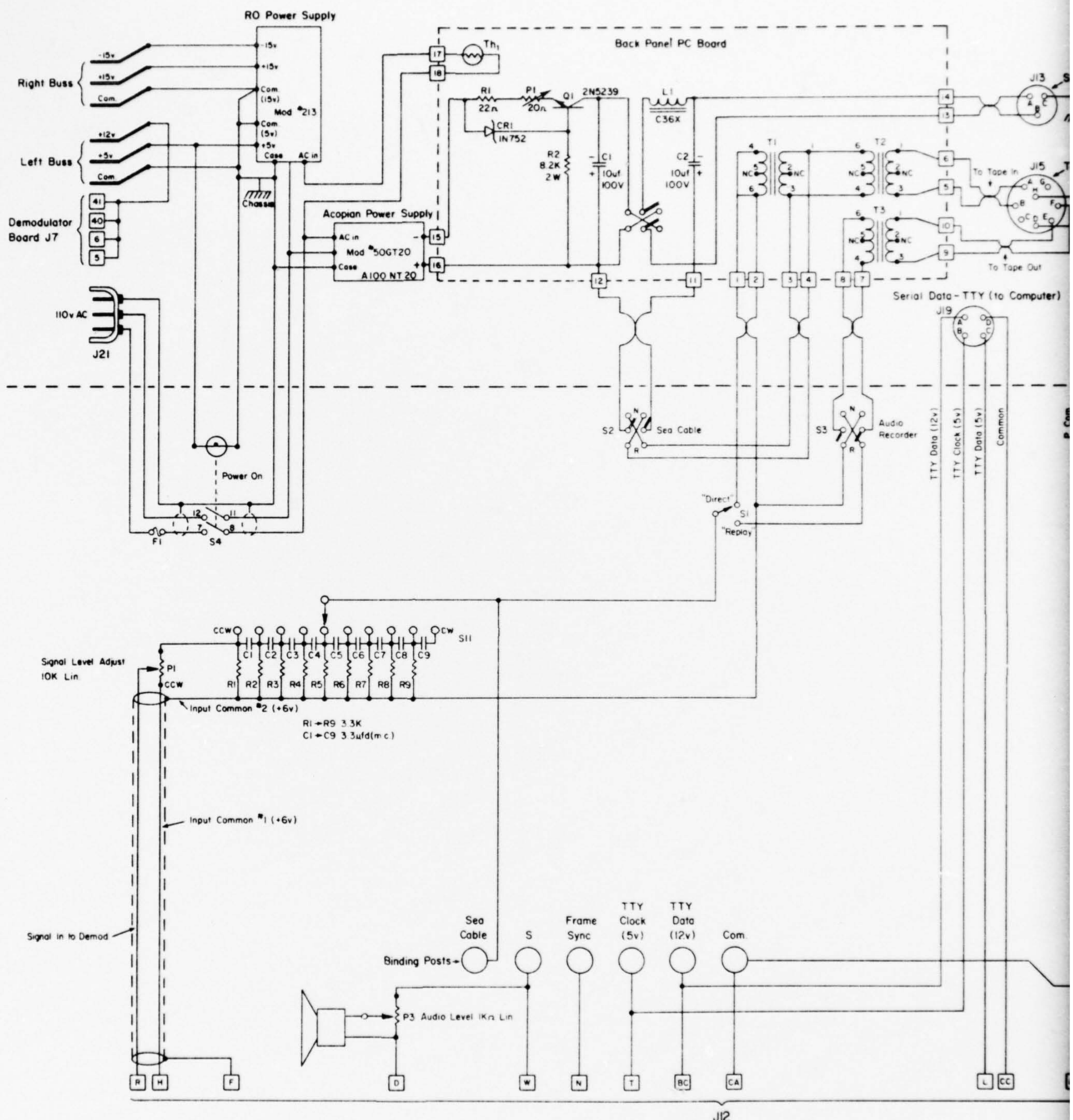
Name of Connector: DEMODULATOR Part Number: P/N 014-PC-02-0 Date:

Fig. 5.2.4(3)

Fig. 5.2.6(2)

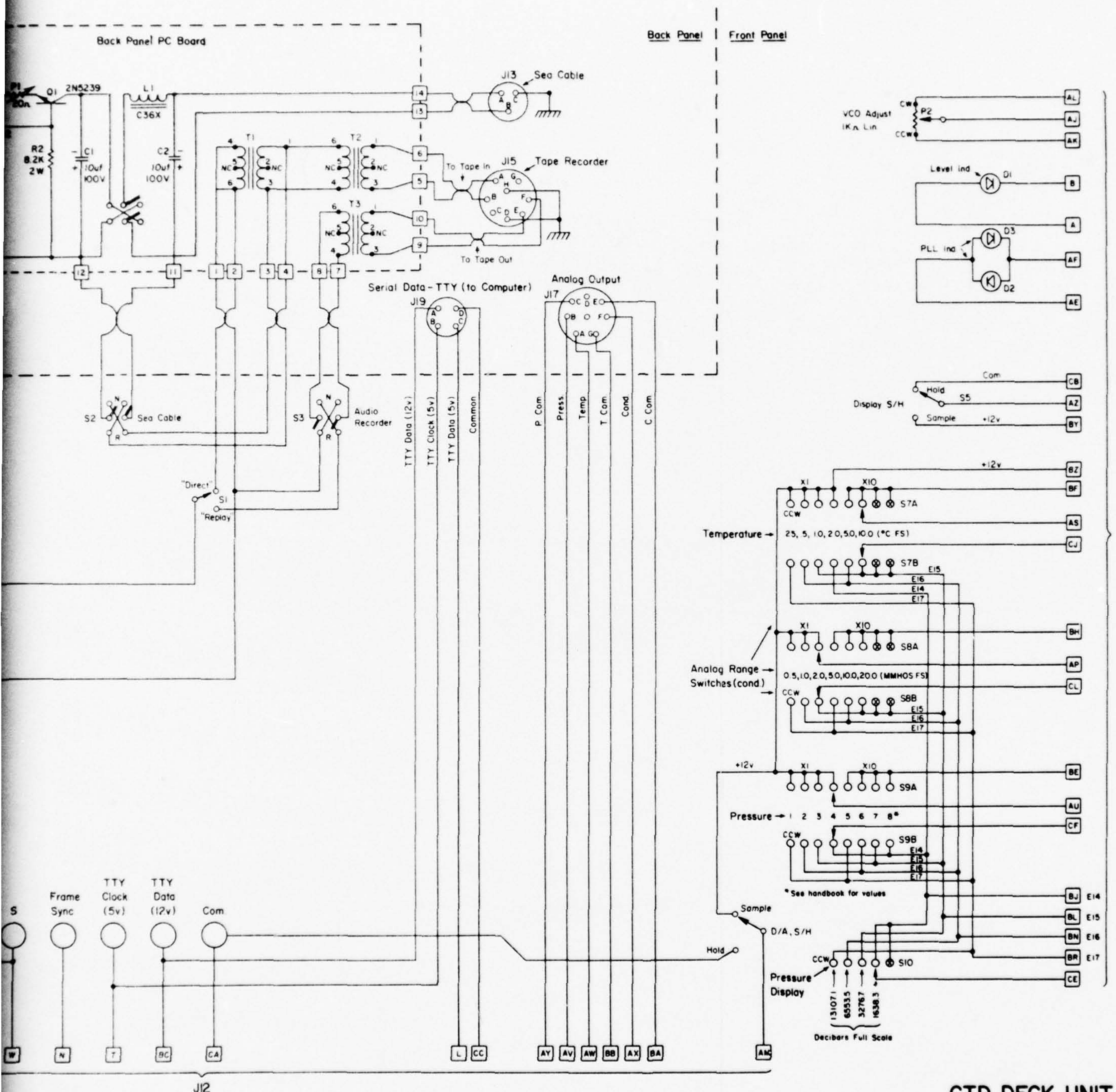


CR1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
T1
T2
T3
R2
R1
R3
Th1
C2
+
+
C1
+
+
Q1
2N5239
S1
L1
+ Voltage
on 14 when in
pos. shown


RO Power Supply
Mod #213
Right Buss
-15v
+15v
Com.
Com. (15v)
Com. (5v)
+5v
Case
AC in
Left Buss
+12v
+5v
Com.
Chassis
Demodulator Board J7
41
40
6
5
110v AC
J21
Acopian Power Supply
AC in
Mod #50GT20
Case
A100 NT20
Back Panel PC Board
Th1
R1 22Ω
P1 20Ω
Q1 2N5239
CR1 1N752
R2 8.2K 2W
C1 10uf 100V
C2 10uf 100V
L1 C36X
T1
T2
T3
NC
J13
J15
To Tape In
To Tape Out
Serial Data - TTY (to Computer)
J19
TTY Data (12v)
TTY Clock (5v)
TTY Data (5v)
Common
S2
Sea Cable
S3
Audio Recorder
Power On
F1
S4
"Direct"
S1
"Replay"
CCW
CW
S11
C1 C2 C3 C4 C5 C6 C7 C8 C9
R1 R2 R3 R4 R5 R6 R7 R8 R9
Signal Level Adjust 10K Lin.
P1
CCW
Input Common #2 (+6v)
R1→R9 3.3K
C1→C9 3.3ufd(mc)
Input Common #1 (+6v)
Signal in to Demod
Sea Cable
S
Frame Sync
TTY Clock (5v)
TTY Data (12v)
Com.
Binding Posts
P3 Audio Level 1KΩ Lin
R H F D W N T BC CA L CC
J12

1

Fig. 5.2.7



CTD DECK UNIT MK III

FRONT/BACK PANEL

12/77

2

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12
A	Level Ind. LED Anode	7L					
B	Level Ind. LED Cathode	11L					
C							
D	Output Common	9L					
E							
F	Input Common #2	12L					
H	Input Common #1	13L					
J							
K							
L	TTY DATA OUT, 5V Level	70L					
M							
N	FRAME SYNC	61L					
P							
R	Signal Input to Demod.	8L					
S							
T	TTY Clk OUT, 5V Level	37R					
U							
V							
W	Audio Output	14L					
X							
Y							
Z							
AA							
AB							
AC							
AD							
AE	Phase Adj LED	30R					
AF	Phase Adj LED	31R					
AH							
AJ	Phase Adj Pot, Center Tap	63R					
AK	Phase Adj Pot. CCW END	64R					
AL	Phase Adj Pot. CW END	65R					
AM	D/A Sample Hold INput			43R			
AN							
AP	X1,X10 Cond. D/A Switch			53L			
AR							
AS	X1,X10 Temp. D/A Switch			54L			
AT							
AU	X1,X10 Press.D/A Switch			55L			
AV	D/A OUTPUT, Pressure			29R			
AW	D/A OUTPUT, Temp.			30R			
AX	D/A OUTPUT, Cond.			31R			
AY	D/A OUT Press Com			2L			
AZ	Display Sample Hold Input				20L		
BA	D/A OUT Cond Com			2L			
BB	D/A OUT Temp Com			37L			
BC	TTY DATA Out 12V Level	66R					

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12
CA	Com from Buss to S/H D/A						
CB	Com from Buss to S/H Display						
CC	Com from Buss to J19						
CD							
CE	Pressure Display Enable				65R		
CF	Enable In Press D/A			42R			
CH							
CJ	Enable In Temp D/A			44R			
CK							
CL	Enable In Cond. D/A			45R			
CM							
CN							
CP							
CR							
CS							
CT							
CU							
CV							
CW							
CX							
CY							
CZ							
DA							
DB							

Fig. 5.2.7(2)

Pin	Function				
Y					
Z					
AA					
AB					
AC					
AD					
AE	Phase Adj LED	30R			
AF	Phase Adj LED	31R			
AH					
AJ	Phase Adj Pot, Center Tap	63R			
AK	Phase Adj Pot. CCW END	64R			
AL	Phase Adj Pot. CW END	65R			
AM	D/A Sample Hold INput			43R	
AN					
AP	X1,X10 Cond. D/A Switch			53L	
AR					
AS	X1,X10 Temp. D/A Switch			54L	
AT					
AU	X1,X10 Press.D/A Switch			55L	
AV	D/A OUTPUT, Pressure			29R	
AW	D/A OUTPUT, Temp.			30R	
AX	D/A OUTPUT, Cond.			31R	
AY	D/A OUT Press Com			2L	
AZ	Display Sample Hold Input				20L
BA	D/A OUT Cond Com			2L	
BB	D/A OUT Temp Com			37L	
BC	TTY DATA Out 12V Level	66R			
BD					
BE	X10 Press. D/A Switch			54R	
BF	X10 Temp. D/A Switch			56R	
BH	X10 Cond. D/A Switch			57R	
BJ	E14, Enable 14		38R		
BK					
BL	E15, Enable 15		39R		
BM					
BN	E16, Enable 16		40R		
BP					
BR	E17, Enable 17		41R		
BS					
BT					
BU					
BV					
BW					
BX					
BY	+12V from Buss to S/H Display				
BZ	+12V from Buss to S/H D/A & X1 Range Switch				
Connector:					

Pin	Function
CY	
CZ	
DA	
DB	
Connector:	

Name of Connector: INTERNAL I/O

Part Number: J12

Date:

2

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp. I/O (J11)	Internal I/O J12
A	16th M.S.B. // OUT	24L					
B	Common					D, Com Buss	
C	15th Bit // OUT	27L					
D	Common					B,F	
E	14th Bit // OUT	28L					
F	Common					D,J	
H	13th Bit // OUT	29L					
J	Common					F,L	
K	12th Bit // OUT	23L					
L	Common					J,N	
M	11th Bit // OUT	22L					
N	Common					L,R	
P	10th Bit // OUT	26L					
R	Common					N,T	
S	9th Bit // OUT	38R					
T	Common					R,V	
U	8th Bit // OUT	31L					
V	Common					T,X	
W	7th Bit // OUT	1R					
X	Common					V,Z	
Y	6th Bit // OUT	2R					
Z	Common					X,AB	
AA	5th Bit // OUT	35L					
AB	Common					Z,AD	
AC	4th Bit // OUT	34L					
AD	Common					AB,AF	
AE	3rd Bit // OUT	33L					
AF	Common					AD,AJ	
AH	2nd Bit // OUT	32L					
AJ	Common					AF,AL	
AK	1st L.S.B. // OUT	30L					
AL	Common					AJ,	
AM	Frame Sync Interrupt	4R					
AN	Common					AR, Com Buss	
AP	Pressure Interrupt	5R					
AR	Common					AN,AT	
AS	Temp. Interrupt	3R					
AT	Common					AR,AV	
AU	Cond. Interrupt	50R					
AV	Common					AT,AZ	
AW	Sign Bits Interrupt	51R					
AX	Common					AV,BP	
AY	Spare Interrupt	49R					
AZ	Spare Interrupt	17R					
BA	Spare Interrupt	18R					
BB	Spare Interrupt	16R					
BC	Spare Interrupt	61R					
BD	**Spare Interrupt**	**62R**					

Pin Num.	Function	Demod. J7 and J8	Num. Conv. J3 and J4	D/A J5 and J6	Display J1 and J2	Comp I/O (J11)	Internal I/O J12
CA	Common					BY,CC	
CB	12th Bit // IN		61L				
CC	Common					CA,CE	
CD	11th Bit // IN		60L				
CE	Common					CC,CH	
CF	10th Bit // IN		59L				
CH	Common					CE,CK	
CJ	9th Bit // IN		58L				
CK	Common					CH,CM	
CL	8th Bit // IN		53L				
CM	Common					CK,CP	
CN	7th Bit // IN		52L				
CP	Common					CM,CS	
CR	6th Bit // IN		51L				
CS	Common					CP,CU	
CT	5th Bit // IN		50L				
CU	Common					CS,CU	
CV	4th Bit // IN		65L				
CW	Common					CU,CY	
CX	3rd Bit // IN		64L				
CY	Common					CW,DA	
CZ	2nd Bit // IN		63L				
DA	Common					CY	
DB	1st L.S.B. // IN		62L				

Fig. 5.2.7(3)

Y	6th Bit // OUT	2R				
Z	Common				X,AB	
AA	5th Bit // OUT	35L				
AB	Common				Z,AD	
AC	4th Bit // OUT	34L				
AD	Common				AB,AF	
AE	3rd Bit // OUT	33L				
AF	Common				AD,AJ	
AH	2nd Bit // OUT	32L				
AJ	Common				AF,AL	
AK	1st L.S.B. // OUT	30L				
AL	Common				AJ,	
AM	Frame Sync Interrupt	4R				
AN	Common				AR, Com Buss	
AP	Pressure Interrupt	5R				
AR	Common				AN,AT	
AS	Temp. Interrupt	3R				
AT	Common				AR,AV	
AU	Cond. Interrupt	50R				
AV	Common				AT,AZ	
AW	Sign Bits Interrupt	51R				
AX	Common				AV,BP	
AY	Spare Interrupt	49R				
AZ	Spare Interrupt	17R				
BA	Spare Interrupt	18R				
BB	Spare Interrupt	16R				
BC	Spare Interrupt	61R				
BD	Spare Interrupt	62R				
BE	Spare Interrupt	60R				
BF	Sensor Address Line		47L			
BH	Sensor Address Line		45L			
BJ	Sensor Address Line		43L			
BK	Sensor Address Line		49L			
BL	SENSE		67L			
BM	SENSE		68L			
BN	STROBE		66L			
BP	Common				AZ,BR	
BR	Common				BU, Com Buss	
BS	Common					
BT	16th Bit // IN		56L			
BU	Common				BS,BW	
BV	15th Bit // IN		57L			
BW	Common				BU,BY	
BX	14th Bit // IN		55L			
BY	Common				BW,CA	
BZ	13th Bit // IN		54L			

Connector: J 11

CY	Common					CW,DA
CZ	2nd Bit // IN		63L			
DA	Common					CY
DB	1st L.S.B. // IN		62L			

Connector: J 11

Name of Connector: COMPUTER I/O Part Number: J11 Date:

2

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PARTS LISTS

PRESSURE INTERFACE
(UWU)
Circuit Board 001-PC-01-1

Capacitors

C3	33	pf	5%	Silver Mica
C4	2000	pf	5%	Silver Mica
C6	10	ufd	10%	Sprague 150D 20v
C7	100	ufd	10%	Sprague 150D 20v
C8	8200	pf	5%	Silver Mica
C9	8200	pf	5%	Silver Mica
C10	T.B.D.		5%	Silver Mica
C11	T.B.D.		5%	Silver Mica

Connector

Elco 7022-035-000-001

Diodes

CR1	1N 914
CR2	1N 914
CR3	1N 914
CR4	1N 914
CR5	1N 914
CR6	1N 914

Inductors

L1 30mH Triad EM-030-A

Integrated Circuits

1C1 CD4011AE Quad NAND Gates

Potentiometers

P1	1	kilohm	Bourns 3009Y
P2	10	kilohm	Bourns 3009Y
P3	20	kilohm	Bourns 3009Y
P4	1	kilohm	Bourns 3009Y
P5	100	ohm	Bourns 3009Y

Resistors

R1	2.21	kilohm	RN60C metal film	1%
R2	2.21	kilohm	RN60C metal film	1%
R3	33	ohm	RN60C metal film	1%
R4	T.B.D.		RN60C metal film	1%
R5	T.B.D.		RN60C metal film	1%
R6	3.32	megohm	RN60C metal film	1%
R7	T.B.D.			
R8	T.B.D.			
R9	33.2	kilohm	RN60C metal film	1%
R10	20	kilohm	RN60C metal film	1%
R11	49.9	kilohm	RN60C metal film	1%
R12	5.62	kilohm	RN60C metal film	1%
R13	47.5	kilohm	RN60C metal film	1%
R14	1	kilohm	RN60C metal film	1%
R15	221	ohm	RN60C metal film	1%
R16	499	ohm	RN60C metal film	1%
R17	221	ohm	RN60C metal film	1%
R18	1	megohm	¼ watt carbon	5%
R19	1	megohm	¼ watt carbon	5%
R20	200	ohm	Vishay	0.1%
R21	T.B.D.			
R22	T.B.D.			

Sockets

1 Augat 514-AG-10D

Transformers

T1	001-T1-01-0	NBIS
T2	001-T2-01-0	NBIS
T3	001-T3-01-0	NBIS

Transistors

Q1	2N 4250
Q2	2N 5089
Q3	2N 4250
Q4	2N 5638
Q5	2N 5089
Q6	2N 5638

TEMPERATURE INTERFACE
(UWU)
Circuit Board 002-PC-01-1

Capacitors

C1	33	pf	5%	Silver Mica
C2	10	ufd	10%	Sprague 150D 20v
C3	100	ufd	10%	Sprague 150D 20v
C4	8200	pf	5%	Silver Mica
C4A	T.B.D.			
C5	8200	pf	5%	Silver Mica
C5A	T.B.D.			

Connector

Elco 7022-035-000-001

Diodes

CR1	1N 914
CR2	1N 914
CR3	1N 914
CR4	1N 914
CR5	1N 914
CR6	1N 914

Hardware

2 #4/40 x 5/8 Nylon Screws
2 #4 Nuts

Inductors

L1 30mH Triad EM-030-A

Integrated Circuits

1C1 CD4011AD Dual input Quad NAND

Potentiometers

P1	5	kilohm	Bourns 3009Y
P2	5	kilohm	Bourns 3009Y
P3	2	kilohm	Bourns 3009Y

Resistors

R1	20	kilohm	RN60C metal film 1%
R2	2	kilohm	RN60C metal film 1%
R3	200	kilohm	RN60C metal film 1%
R4	49.9	kilohm	RN60C metal film 1%
R5	5.62	kilohm	RN60C metal film 1%
R6	47.5	kilohm	RN60C metal film 1%
R7	1	kilohm	RN60C metal film 1%
R8	499	ohm	RN60C metal film 1%
R9	392	ohm	RN60C metal film 1%
R10	392	ohm	RN60C metal film 1%
R11	1	megohm	¼ watt carbon 5%
R12	44.84	ohm	Vishay 0.1%
R13	300	ohm	Vishay 0.1%
R14	4.99	kilohm	RN60C metal film 1%
R15	1	megohm	¼ watt carbon 5%
R16	33.2	kilohm	RN60C metal film 1%

Sockets

1 Augat 514-AG-10D

Transformers

T2	002-T2-01-0	NBIS
T3	002-T3-01-0	NBIS

Transistors

Q1	2N 4250
Q2	2N 5089
Q3	2N 4250
Q4	2N 5638
Q5	2N 5089
Q6	2N 5638

NOTE:

Fishay Resistor R_F is situated in the Sensor Housing.

$R_F = 10 \ (R_{01} + R_{02}) \ (\pm \ 0.1\%)$

R_{01} + resistance of thermometer element 1 at 0^oC

R_{02} = resistance of thermometer element 2 at 0^oC

FAST RESPONSE SENSOR
(UWU)
Circuit Board 003-PC-01-1

Capacitors

C1	50	pf	5%	Silver Mica
C2	1.0	ufd	10%	TRW 50v
C3	10	ufd	10%	Sprague 150D 20v
C4	10	pf	5%	Silver Mica
C5	1.0	ufd	10%	TRW 50v
C6	8200	pf	5%	Silver Mica
C7	0.1	ufd	10%	TRW 50v
C8	0.1	ufd	10%	TRW 50v
C9	.0033	ufd	10%	Sprague 192P 80v
C10	0.1	ufd	10%	TRW 50v
C11	30	pf	5%	Silver Mica
C12	1.8	ufd	10%	TRW 50v
C13	0.1	ufd	10%	TRW 50v
C14	330	pf	5%	Silver Mica
C15	100	ufd	10%	Sprague 150D 10v

Connector

Elco 7022-035-000-001

Diodes

CR1	1N 914
CR2	1N 914

Inductors

L1 003-L1-01-0 NBIS

Integrated Circuits

1C1	MEM780P Gen. Inst. Quad MOSFET
1C2	uA749DC Fairchild Dual Op. Amp.
1C3	MEM780P Gen. Inst. Quad MOSFET
1C4	LM208AD Nat. Semi. Op. Amp.

Potentiometers

P1	10	kilohm	Bourns 3009Y
P2	10	kilohm	Bourns 3009Y

Resistors
¼ watt carbon 5% (unless noted)

R1	1.91	kilohm	RN60C metal film 1%
R2	100	kilohm	
R3	22	kilohm	

Resistors (con't)

R4	10	kilohm
R5	470	ohm
R6	100	kilohm
R7	220	ohm
R8	3.3	kilohm
R9	270	kilohm
R10	270	kilohm
R11	10	kilohm
R12	100	kilohm
R13	100	kilohm
R14	4.7	ohm
R15	10	kilohm
R16	1	kilohm
R17	1	kilohm
R18	10	ohm
R18A	T.B.D.	
R19	180	ohm
R19A	T.B.D.	
R20	1	kilohm
R21	10	ohm

Sockets

3 Augat #514-AG-10D

Terminal Post

1 Cambion #160-1043-03-01

Transformers

T1	003-T1-01-0 NBIS
T2	003-T2-01-0 NBIS

CONDUCTIVITY INTERFACE
(UWU)
Circuit Board 004-PC-01-2

Capacitors

C1	10	ufd	10%	Sprague 150D 20v
C2	100	ufd	10%	Sprague 150D 20v
C3	390	pf	5%	Silver Mica
C4	8200	pf	5%	Silver Mica
C4A	T.B.D.			
C5	8200	pf	5%	Silver Mica
C5A	T.B.D.			
C6	10	ufd	10%	Sprague 150D 20v
C7	8200	pf	5%	Silver Mica
C7A	T.B.D.			
C8	8200	pf	5%	Silver Mica
C8A	T.B.D.			
C9	100	ufd	10%	Sprague 150D 20v
C10	.0018	ufd	10%	Sprague 192P

Connector

Elco 7022-035-000-001

Diodes

CR1	1N 914
CR2	1N 914
CR3	1N 914
CR4	1N 914
CR5	1N 914
CR6	1N 914

Hardware

2	#4/40 x 5/8 Nylon Screws
2	#4 Nuts

Inductors

L1	30 mH	Triad EM-030-A
L2	30 mH	Traid EM-030-A

Potentiometers

P1	5	kilohm Bourns 3009Y
P2	1	kilohm Bourns 3262P

Resistors

RN60C metal film (unless noted) 1%

R1	49.9	kilohm
R2	49.9	kilohm
R3	4.99	kilohm
R4	1	kilohm
R5	392	ohm
R6	392	ohm
R7	1	kilohm
R8	47.5	kilohm
R9	49.9	kilohm
R10	40	kilohm RN55C
R11	10.0	kilohm RN55C
R12	1	kilohm
R13	33.2	kilohm
R14	5.62	kilohm
R15	499	ohm
R16	1	megohm
R17	4.9	kilohm Vishay S102 .01%
R18	33.2	kilohm

Sockets

1	Augat #616-CG-1
1	Augat #516-AG-D

Transformers

T1	004-T1-01-0 NBIS
T2	004-T2-01-0 NBIS
T3	004-T3-01-0 NBIS
T4	004-T4-01-0 NBIS

Transistors

Q1	2N 4122
Q2	2N 5089
Q3	2N 4250
Q4	2N 4250
Q5	2N 5638
Q6	2N 5089
Q7	2N 4122
Q8	2N 5089

OXYGEN BOARD

Circuit Board 020-PC-01-0

Capacitors

C1	.33	ufd	10% Miniature Ceramic
C2	.01	ufd	10% Miniature Ceramic
C3	10	ufd	10% Sprague 150D 20v
C4	.047	ufd	10% Miniature Ceramic
C5	470	pf	5% Silver Mica
C6	.022	ufd	192P Sprague
C7	200	pf	5% Silver Mica
C8	200	pf	5% Silver Mica
C9	200	pf	5% Silver Mica
C10	200	pf	5% Silver Mica

Connectors

1	Elco #7022-35-000-001
3	Augat #508-AG-1D
4	Augat #514-AG-10D
7	Augat #516-AG-10D

Diodes

D1	1N 914
D2	1N 914
D3	1N 914
D4	1N 914
D5	LVA 43A Zener

Integrated Circuits

IC1	uA 776TC
IC2	LF 355H
IC3	uA 776TC
IC4	CD 4066 AE
IC5	CD 4013 AE
IC6	MC 14572 CP
IC7	CD 4021 AE
IC8	CD 4021 AE
IC9	CD 4040 AE
IC10	CD 4024 AE
IC11	CD 4013 AE
IC12	CD 4015 AE
IC13	CD 4021 AE
IC14	CD 4029 AE

Potentiometers

P1	100	kilohms Bourns 3009Y
P2	50	kilohms Bourns 3009Y
P3	100	kilohms Bourns 3009Y
P4	20	kilohms Bourns 3009Y

Regulators

Z1	AD 580

Resistors

R1	10	kilohms ¼ w carbon, 5%
R2	68.1	kilohms RN60C Metal Film
R3	22.1	kilohms RN60C Metal Film
R4	22	megohms ¼ w carbon, 5%
R5	1.2	megohms RN60C Metal Film
R6	100	kilohms RN60C Metal Film
R7	499	kilohms RN60C Metal Film
R8	22	megohms ¼ w carbon, 5%
R9	392	kilohms RN60C Metal Film
R10	47.5	kilohms RN60C Metal Film
R11	33	kilohms ¼ w carbon, 5%
R12	33	kilohms ¼ w carbon, 5%
R13	220	kilohms ¼ w carbon, 5%
R14	33	kilohms ¼ w carbon, 5%
R15	22	kilohms ¼ w carbon, 5%
R16	220	kilohms ¼ w carbon, 5%

Transistors

Q1	2N 4401
Q2	2N 4401

Transformers

T1	Triad, Sp-67

POWER SUPPLY
(UWU)
Circuit Board 008-PC-01-0

Capacitors

C1	100	pf	5% Silver Mica
C2	1000	ufd	Sprague 39D 10v
C3	10	ufd	Sprague 150D 50v
C4	.1	ufd	10% TRW 50v
C5	100	ufd	Sprague 150D 20v
C6	1	ufd	10% TRW 50v
C7	2500	ufd	Sprague 39D 15v
C8	.0018	ufd	10% Sprague 192P 200v

Connector

Elco	7022-035-000-001

Diodes

CR1	1N458A
CR2	1N914
CR3	1N914
CR4	1N914
CR5	1N941 (Zener)

Hardware

2	Screws/Pan Head	2/56 x ¼
2	Hex nuts	#2
2	Inter. Tooth	#2

Integrated Circuits

1C1	Au723	Fairchild Op. Amp.

Potentiometers

R6	500	ohm	Bourns 3009Y

Resistors
¼ watt carbon, 5%

R1	27	ohm
R2	1.5	kilohm

Resistors (con't)

R3	10	kilohm
R4	100	kilohm
R5	470	ohm
R7	2.7	kilohm
R8	560	ohm
R9	15	ohm
R10	560	ohm
R11	4.7	ohm
R12	560	ohm
R13	1	kilohm
R14	4.7	kilohm
R15	220	ohm
R16	470	ohm
R17	470	ohm
R18	470	ohm
R19	10	kilohm

Sockets

1	Augat #514-AG-10D

Transistors

Q1	2N3638A
Q2	2N3566
Q3	2N4122
Q4	2N3566
Q5	2N4912
Q6	2N4122
Q7	2N3566

A.C. COMPARATOR AND AUTOMATIC QUADRATURE BALANCE
(UWU)
Circuit Board 005-PC-01-1

Capacitors

C1	1000	pf	2%	Silver Mica	
C2	5	pf	5%	Silver Mica	
C3	.01	ufd	10%	Sprague 192P	80v
C4	.033	ufd	10%	Sprague 192P	80v
C5	.001	ufd	10%	Sprague 192P	200v
C6	.01	ufd	10%	Sprague 192P	80v
C7	330	pf	5%	Silver Mica	
C8	100	ufd	10%	Sprague 150D	20v
C9	.018	ufd	10%	Sprague 192P	80v
C10	.0039	ufd	10%	Sprague 192P	80v
C11	10	pf	5%	Silver Mica	
C12	390	pf	5%	Silver Mica	

Connector

Elco 7022-035-000-001

Diodes

CRL	1N 914
CR2	1N 914
CR3	1N 914
CR4	1N 914
CR5	1N 914
CR6	1N 914

Integrated Circuits

1C1	749DC	Fairchild Dual Op. Amp.
1C2	749DC	Fairchild Dual Op. Amp.
1C3	776TC	Fairchild Dual Op. Amp.
1C4	777TC	Fairchild Dual Op. Amp.
1C5	796HC	Fairchild Dual Op. Amp.
1C6	MEM780P	Gen. Inst. Quad Mosfet

Potentiometers

P1	100	kilohm	Bourns	3009Y
P2	10	kilohm	Bourns	3009Y
P3	100	kilohm	Bourns	3009Y

Sockets

3	Augat #514-AG-10D
2	Augat #508-AG-1-D

Terminal Post

4 Cambion #160-1043-03-01

Transformers

T1	005-T1-01-0	NBIS
T2	005-T2-01-0	NBIS

Resistors

R1	10	kilohm	¼ watt	carbon	5%
R2	47	ohm	¼ watt	carbon	5%
R3	10	kilohm	¼ watt	carbon	5%
R4	10	kilohm	¼ watt	carbon	5%
R5	33	kilohm	¼ watt	carbon	5%
R6	330	ohm	¼ watt	carbon	5%
R7	3.3	kilohm	¼ watt	carbon	5%
R8	150	kilohm	¼ watt	carbon	5%
R9	1	kilohm	¼ watt	carbon	5%
R10	10	kilohm	RN60C	metal film	1%
R11	10	kilohm	RN60C	metal film	1%
R12	10	kilohm	RN60C	metal film	1%
R13	3.3	kilohm	¼ watt	carbon	5%
R14	15	ohm	¼ watt	carbon	5%
R15	1	kilohm	¼ watt	carbon	5%
R16	18	kilohm	¼ watt	carbon	5%
R17	33	ohm	¼ watt	carbon	5%
R18	1	kilohm	¼ watt	carbon	5%
R19	33.2	kilohm	RN60C	metal film	1%
R20	22	kilohm	¼ watt	carbon	5%
R21	3.3	kilohm	¼ watt	carbon	5%
R22	4.7	kilohm	¼ watt	carbon	5%
R23	33.2	kilohm	RN60C	metal film	1%
R24	33.2	kilohm	RN60C	metal film	1%
R25	33.2	kilohm	RN60C	metal film	1%
R26	10	kilohm	RN60C	metal film	1%
R27	10	kilohm	RN60C	metal film	1%
R28	10	kilohm	RN60C	metal film	1%
R29	3.3	kilohm	¼ watt	carbon	5%
R30	15	ohm	¼ watt	carbon	5%
R31	1	kilohm	¼ watt	carbon	5%
R32	33.2	kilohm	RN60C	metal film	1%
R33	33.2	kilohm	RN60C	metal film	1%
R34	33.2	kilohm	RN60C	metal film	1%
R35	33.2	kilohm	RN60C	metal film	1%
R36	10	kilohm	RN60C	metal film	1%
R37	220	ohm	¼ watt	carbon	5%
R38	1	megohm	¼ watt	carbon	5%
R39	15	kilohm	¼ watt	carbon	5%
R40	18	kilohm	¼ watt	carbon	5%

A.C. COMPARATOR AND AUTOMATIC QUADRATURE BALANCE (con't)

Resistors (con't)

R41	10	megohm, ¼ watt carbon, 5%
R42	470	ohm, ¼ watt carbon, 5%
R43	470	ohm, ¼ watt carbon, 5%
R44	15	kilohm, ¼ watt carbon, 5%
R45	1	kilohm, ¼ watt carbon, 5%
R46	820	kilohm, ¼ watt carbon, 5%

D/A CONVERTER
(UWU)
Circuit Board 006-PC-01-1

Connector

Elco	7022-035-000-001

Integrated Circuits

1C1	CD4049AE	Hex Inverting Buffer
1C2	CD4049AE	Hex Inverting Buffer
1C3	CD4049AE	Hex Inverting Buffer

Resistors

R1	33	ohm, ¼ watt carbon, 5%
R2	33	ohm, ¼ watt carbon, 5%

Sockets

3	Augat #516-AG-10D

Transformers

T1	006-T1-01-0
T2	006-T2-01-0
T3	006-T3-01-0

Transistors

Q1	2N 5638
Q2	2N 5638
Q3	2N 5638
Q4	2N 5638
Q5	2N 5638
Q6	2N 5638
Q7	2N 5638
Q8	2N 5638
Q9	2N 5638
Q10	2N 5638
Q11	2N 5638
Q12	2N 5638
Q13	2N 5638
Q14	2N 5638
Q15	2N 5638

Transistors (con't)

Q16	2N 5638
Q17	2N 5638
Q18	2N 5638
Q19	2N 5638
Q20	2N 5638
Q21	2N 5638
Q22	2N 5638
Q23	2N 5638
Q24	2N 5638
Q25	2N 5638
Q26	2N 5638
Q27	2N 5638
Q28	2N 5638
Q29	2N 5638
Q30	2N 5638
Q31	2N 5638
Q32	2N 5638

DIGITIZER LOGIC AND QUADRATURE MEMORY
(UWU)
Circuit Board 007-PC-01-1

Connector

Elco 7022-035-000-001

Diodes

CR1	1N914)	
CR2	1N914)	Optional Use
CR3	1N914)	
CR4	1N914)	

Integrated Circuits

1C1	MC14549CP	Successive approximation Register
1C2	CD4021AE	Shift Register
1C3	MC14549CP	Successive approximation Register
1C4	CD4021AE	Shift Register
1C5	CD4013AE	D type Flip-Flip (dual)
1C6	CD4013AE	D type Flip-Flop (dual)
1C7	MEM780P	Quad MOSFET (optional use)

Sockets

4	Augat	#514-AG-10D
4	Augat	#516-AG-10D

Terminal Post

1	Cambion	#160-1043-03-01

MEMORY AND MULTIPLEXER
(UWU)
Circuit Board 010-PC-01-1

Capacitors

C1	220	pf	5%	Silver Mica
C2	330	pf	5%	Silver Mica
C3	330	pf	5%	Silver Mica
C4	.001	ufd	10%	Miniature Ceramic
C5	330	pf	5%	Silver Mica
C7	220	pf	5%	Silver Mica
C8	.082	ufd	10%	Miniature Ceramic
C9	.001	ufd	10%	Miniature Ceramic

Resistors
¼ watt carbon 5%

R1	10	kilohm
R2	10	kilohm
R3	10	kilohm
R4	10	kilohm
R5	10	kilohm
R7	10	kilohm
R8	68	kilohm
R9	10	kilohm

Connector

Elco 7022-035-000-001

Sockets

4	Augat #514-AG-10D
8	Augat #516-AG-10D
2	Augat #524-AG-10D

Diodes

CR1	1N 914
CR2	1N 914

Integrated Circuits

1C1	CD4039AE	Random Access Memory
1C2	CD4039AE	Random Access Memory
1C3	CD4021AE	Shift Register
1C4	CD4021AE	Shift Register
1C5	CD4021AE	Shift Register
1C6	CD4021AE	Shift Register
1C7	CD4021AE	Shift Register (Optional)
1C8	CD4021AE	Shift Register (Optional)
1C9	CD4019AE	AND/OR Select Gates
1C10	CD4017AE	Counter
1C11	CD4013AE	Flip-Flop
1C12	CD4013AE	Flip-Flop
1C13	CD4013AE	Flip-Flop
1C14	CD4013AE	Flip-Flop

MARK III and MARK IIIb CTD ADAPTIVE SAMPLING BOARD
(UWU)
NBIS Assembly Number C10009

Capacitors

C1	.1 ufd 10% minature ceramic
C2	.01 ufd 10% minature ceramic

Resistors

R1	3.3	kilohms	¼ watt	carbon	5%
R2	33	kilohms	¼ watt	carbon	5%
R3	33	kilohms	¼ watt	carbon	5%
R4	10	kilohms	¼ watt	carbon	5%
R5	3.3	kilohms	¼ watt	carbon	5%
R6	33	kilohms	¼ watt	carbon	5%
R7	22	kilohms	¼ watt	carbon	5%
R8	33	kilohms	¼ watt	carbon	5%

Circuit Board

30006-

Connector

Elco 7022

Transistors

Q1	2N 4124
Q2	2N 4126
Q3	2N 4126
Q4	2N 4124
Q5	2N 4124

Diodes

CR1 1N 914

Integrated Circuits

IC1	CD4017AE	Counter
IC2	CD4013AE	Flip-Flop
IC3	CD4013AE	Flip-Flop
IC4	CD4071BE	Quad OR
IC5	CD4013AE	Flip-Flop
IC6	CD4013AE	Flip-Flop
IC7	CD4021AE	Shift Register
IC8	CD4081BE	Quad AND
IC9	CD4017AE	Counter

TTY-FSK
(UWU)
Circuit Board 014-PC-01-0

Capacitors

C1	220	pf	5%	Silver Mica
C2	.082	ufd	10%	Miniature Ceramic
C3	1	ufd	10%	TRW 50v
C4	.15	ufd	10%	Miniature Ceramic
C5	1	ufd	10%	TRW 50v
C6	.33	ufd	10%	Miniature Ceramic
C7	100	ufd	10%	Sprague 150D 10v
C8	470	pf	5%	Silver Mica

Connectors

1	Elco #7022-35-000-001
9	Augat #514-AG-10D
6	Augat #516-AG-10D

Integrated Circuits

IC1	CD4017AE	Counter
IC2	CD4013AE	Flip-Flop
IC3	CD4013AE	Flip-Flop
IC4	CD4066AE	Quad Bilateral Switch
IC5	CD4015AE	Shift Register
IC6	CD4001AE	Quad NOR Gates
IC7	CD4049AE	Hex Buffer
IC8	CD4021AE	Shift Register
IC9	CD4013AE	Flip-Flop
IC10	CD4017AE	Counter
IC11	CD4068AE	Input NAND Gates
IC12	CD4013AE	Flip-Flop
IC13	CD4025AE	
IC14	CD4024AE	Counter

Resistors

¼watt carbon 5% (unless noted)

R1	10	kilohm	
R2	18.2	kilohm	RN60C Metal Film
R3	18.2	kilohm	RN60C Metal Film
R4	18.2	kilohm	RN60C Metal Film
R5	18.2	kilohm	RN60C Metal Film
R6	2.2	kilohm	
R7	3.3	kilohm	
R8	1.8	kilohm	
R9	82	ohm	
R10	12	kilohm	
R11	12	kilohm	

Resistors (con't)

R12	33	kilohm
R13	33	kilohm
R14	33	kilohm
R15	33	kilohm
R16	33	kilohm
R17	33	kilohm
R18	33	kilohm

Switches

1	CTS #206-8

Transformers

1	014-T1-01-0 NBIS

Transistors

Q1	AD 811
Q2	2N 4401

SIGNAL GENERATOR
CIRCUIT BOARD 30001

Capacitors

C1	220	pf	5% Silver Mica
C2	62	pf	5% Silver Mica
C3	TBD		
C4	5000	pf	5% Silver Mica
C5	.47	ufd	TRW
C6	TBD		
C7	.1	ufd	TRW
C8	.0033	ufd	192P, Sprague
C9	.022	ufd	192P, Sprague
C10	.1	ufd	TRW
C11	.022	ufd	192P, Sprague
C12	10	ufd	10% Sprague 150D, 20v
C13	10	pf	5% Silver Mica
C14	10	pf	5% Silver Mica

Connectors

3	Augat #514-AG-10D
2	Augat #516-AG-10D
1	Elco #7022-035-000-001

Crystals

1	640 KHZ

Inductors

L1	Sig. Gen. L1
L2	82uf, WEE 82

Integrated Circuits

IC1	CD 4017 AE
IC2	CD 4040 AE
IC3	CD 4024 AE
IC4	CD 4013 AE
IC5	Ua 749

Resistors

¼ watt carbon, 5%

R1	1.5	megohm
R2	47	ohm
R3	3.9	kilohm
R4	33	kilohm
R5	100	kilohm

Resistors (con't)

R6	3.3	kilohm
R7	33	kilohm
R8	33	kilohm
R9	3.3	kilohm
R10	10	kilohm
R11	27	kilohm
R12	27	kilohm
R13	10	kilohm
R14	470	kilohm
R15	33	ohm
R16	3.3	kilohm
R17	10	kilohm
R18	10	kilohm
R19	33	ohm
R20	3.3	kilohm

Terminal Post

4	Cambion #140-1785-02-01-00

Transformers

T1	Sig. Gen. #013-T1-01-3

Transistors

Q1	2N 5089
Q2	2N 4122
Q3	2N 3566
Q4	2N 4401

SENSOR HEAD ASSEMBLY

1		BULKHEAD SEAL BLOCK, NBIS #005-SS-01-0
1		SENSOR CLAMP, NBIS #006-SS-01-0
1		SENSOR SEAL BLOCK, NBIS #007-SS-01-0
1		SENSOR MOUNTING BLOCK, NBIS #008-SS-01-0
1		SENSOR GUARD, NBIS #009-SS-01-0
1		SENSOR HEAD BASE, NBIS #010-SS-01-0
1		SENSOR BASE, NBIS #011-SS-01-0
1		SENSOR BASE COVER, NBIS #012-SS-01-0
1	*	OXYGEN ADAPTOR, NBIS #013-SS-01-0
1		CONDUCTIVITY PLUG ASSEMBLY, NBIS #003-CP-01-0
1		THERMISTOR PLUG ASSEMBLY, NBIS #004-CP-01-0
1		CONDUCTIVITY CELL ASSEMBLY, NBIS #001-CC-01-0
1		THERMISTOR ASSEMBLY, NBIS #002-TC-01-0
1		TRANSFORMER, NBIS #002-T1-01-0
1		CIRCUIT BOARD, NBIS #019-PC-01-0
1		THERMOMETER, ROSEMONT #171BJ
18		CAMBION TERMINAL POST, #140-1785-02-01-00
16		HERMETIC SEAL CORP., SEALS #1045-954
12'		COONER WIRE, #NMV 2/28-736 SJ, Double
4'		COONER WIRE, #NMV 1/28-736 SJ, Single
32"		COONER WIRE, #NUF 32-740
2		"O" RINGS, #ARP 568-032
1		"O" RINGS, #ARP 568-303
1		"O" RINGS, #ARP 568-024
2		"O" RINGS, #ARP 568-010
4		SCREWS, 4/40 x $\frac{1}{2}$, Filister socket, S/S
2		SCREWS, 10/32 x 3/8, Panhead, S/S
2		INTERNAL TOOTH LOCKWASHERS, #10
3		SCREWS, $\frac{1}{4}$ x 28 x 2, Cap, S/S
1		SOCKET WRENCH (3/32 Hex Key)

<u>* OPTIONAL</u>   NOTE: If #013-SS-01-0 is used, #012-SS-01-0 is not required.

T.B.D. VISHAY RESISTORS:

HP 202	1.8534 kilohms)	
	1.8542 kilohms)	.01%
	1.8526 kilohms)	

229

UNDERWATER UNIT ELECTRONICS CHASSIS

End Plates B10031	2 each
Right Card Guide B10032	1 each
Left Card Guide B10033	1 each
Card Guide B10034	1 each
Connector #00-7008-035-163-001	13 each
Screws #4/40 x 5/8 Pan Head	26 each
Nuts #4	26 each
Internal Tooth Lockwashers #4	26 each
Screws #6/32 x 3/8 Flat Head	8 each
Screws #6/32 x3/8 Pan Head	8 each
Internal Tooth Lockwashers #6	8 each
Ground Lug #6	1 each
Connector #XSG-2-IDC-2	1 each
Connector #PT-06A-8-4P(SR)	1 each
Diode #1N2986	1 each
Bottom End Cap B10030	1 each
Top Cap B10029	1 each
Pressure Case B10028-G1	1 each
Rochester Connector #XSG-2BCL	1 each
V-Band Clamps 420-3-712	2 each
Guard Cage B10044	1 each
Rochester Connector #RMG-2-FS	1 each
Rochester Connector #G-FLS-P	1 each
Sea Data Extender Card #DA21	1 each
Crate	1 each
Hex Wrench 3/32	1 each

DECK UNIT
DISPLAY CARD
Circuit Board 016-PC-02-1

Hardware

2	Ejectors w/pins
12	Cambion Terminal Post #160-1043-03-01
18	Display #HP-5082-7302 (*40)
2	Display #HP-5082-7304 (*4)

Integrated Circuits

1C1	CD4050AE	Hex Buffer
1C2	CD4050AE	Hex Buffer
1C3	CD4050AE	Hex Buffer
1C4	CD4050AE	Hex Buffer
1C5	CD4019AE	Quad AND/OR Select Gate
1C6	CD4050AE	Hex Buffer
1C7	CD4050AE	Hex Buffer
1C8	CD4050AE	Hex Buffer
1C9	CD4050AE	Hex Buffer
1C10	CD4012AE	Dual 4 Input NAND Gate
1C11	CD4012AE	Dual 4 Input NAND Gate
1C12	CD4012AE	Dual 4 Input NAND Gate
1C13	CD4050AE	Hex Buffer
1C14	CD4050AE	Hex Buffer
1C15	SN74174N	Hex Latch
1C16	CD4012AE	Dual 4 Input NAND Gate
1C17	CD4012AE	Dual 4 Input NAND Gate
1C18	SN74174N	Hex Latch
1C19	CD4012AE	Dual 4 Input NAND Gate

Resistors
¼ watt carbon, 5%

*R1	330	ohm
*R2	330	ohm
R3	330	ohm
R4	330	ohm
*R5	330	ohm
*R6	330	ohm
R7	330	ohm
R8	330	ohm
*R9	330	ohm
*R10	330	ohm
*R11	330	ohm
*R12	330	ohm
*R13	150	ohm
R14	150	ohm
R15	150	ohm
R16	150	ohm

Resistors (con't)

*R17	150	ohm
*R18	150	ohm

Sockets

6	Jermyn #A23-2023 (*8)
3	Jermyn #A23-2030 (*4)
6	Augat #514-AG-10D
13	Augat #516-AG-10D

NOTE: * OPTIONAL USE

DECK UNIT
NUMBER CONVERTER
Circuit Board 015-PC-02-0

Capacitors

C1	100	pf	5%	Silver Mica
C2	100	pf	5%	Silver Mica
C3	330	pf	5%	Silver Mica
C4	100	pf	5%	Silver Mica

Hardware

2	Ejectors w/pins
4	Cambion Terminal Post #140-1785-02-01

Integrated Circuits

1C1	SN74165	Shift Register
1C2	CD4919AE	Quad AND/OR Select Gates
1C3	CD4035AE	4 Stage Shift Register
1C4	CD4035AE	4 Stage Shift Register
1C5	CD4035AE	4 Stage Shift Register
1C6	CD4035AE	4 Stage Shift Register
1C7	CD4035AE	4 Stage Shift Register
1C8	SN74165	Shift Register
1C9	CD4019AE	Quad AND/OR Select Gates
1C10	CD4008AE	4 Bit Full Adder
1C11	CD4008AE	4 Bit Full Adder
1C12	CD4008AE	4 Bit Full Adder
1C13	CD4008AE	4 Bit Full Adder
1C14	CD4008AE	4 Bit Full Adder
1C15	SN7402	Quad 2 Input NOR Gates
1C16	CD4017AE	Decade Counter
1C17	CD4023AE	Triple 3 Input NAND Gates
1C18	CD4023AE	Triple 3 Input NAND Gates
1C19	CD4023AE	Triple 3 Input NAND Gates
1C20	CD4023AE	Triple 3 Input NAND Gates
1C21	CD4023AE	Triple 3 Input NAND Gates
1C22	CD4050AE	Hex Buffer
1C23	CD4011AE	Quad 2 Input NAND Gates
1C24	CD4013AE	Dual D type Flip-Flop
1C25	CD4013AE	Dual D type Flip-Flop
1C26	CD4013AE	Dual D type Flip-Flop
1C27	CD4049AE	Inverting Hex Buffer
1C28	CD4011AE	Quad 2 Input NAND Gates
1C29	CD4013AE	Dual D type Flip-Flop
1C30	CD4001AE	Quad 2 Input NOR Gates
1C31	CD4013AE	Dual D type Flip-Flop
1C32	CD4011AE	Quad 2 Input NAND Gates

Potentiometers

P21	5 Kilohm	Bourns	3009Y

Resistors
¼ watt carbon, 5%

R1	10	kilohm
R2	10	kilohm
R3	3.3	kilohm
R4	10	kilohm
R5	10	kilohm
R6	3.3	kilohm
R7	10	kilohm
R8	10	kilohm
R9	3.3	kilohm
R10	10	kilohm
R11	10	kilohm
R12	3.3	kilohm
R13	10	kilohm
R14	10	kilohm
R15	3.3	kilohm
R16	10	kilohm
R17	10	kilohm
R18	3.3	kilohm
R19	10	kilohm
R20	10	kilohm
R21	10	kilohm
R22	15	kilohm
R23	2.2	kilohm

Sockets

15	Augat #514-AG-10D
17	Augat #516-AG-10D

Transistors

Q1	2N 2369
Q2	2N 2369
Q3	2N 2369
Q4	2N 2369
Q5	2N 2369
Q6	2N 2369

DECK UNIT
D/A CONVERTER
Circuit Board 017-PC-02-1

Hardware

2	Ejectors w/pins
4	Cambion Terminal Post #160-1043-03-01

Integrated Circuits

1C1	CD4023AE	TRI 3 Input NOR Gates
1C2	CD4011AE	Quad 2 Input NAND Gates
1C3	CD4019AE	Quad AND/OR Select Gates
1C4	CD4019AE	Quad AND/OR Select Gates
1C5	CD4019AE	Quad AND/OR Select Gates
1C6	CD4050AE	Hex Non-Inverting Buffer
1C7	CD4001AE	Quad 2 Input NOR Gates
1C8	CD4050AE	Hex Non-Inverting Buffer
1C9	CD4023AE	TRI 3 Input NOR Gates
1C10	CD4050AE	Hex Buffer
1C11	SN74174AE	Hex D type Flip-Flop
1C12	SN74174AE	Hex D type Flip-Flop
1C13	SN74174AE	Hex D type Flip-Flop
1C14	SN74174AE	Hex D type Flip-Flop
1C15	SN74174AE	Hex D type Flip-Flop
1C16	SN74174AE	Hex D type Flip-Flop
1C17	DAC-372	Hybrid Systems D/A Converter
1C18	DAC-372	Hybrid Systems D/A Converter
1C19	DAC-372	Hybrid Systems D/A Converter

Sockets

4	Augat #514-AG-10D
12	Augat #516-AG-10D

DECK UNIT DEMODULATOR

Circuit Board 014-PC-02-1

Capacitors

C1	.047	ufd	10%	Sprague 192P 80v
C2	.47	ufd	10%	TRW 50v
C3	.0047	ufd	10%	Miniature Ceramic
C4	.022	ufd	10%	Miniature Ceramic
C5	.022	ufd	10%	Miniature Ceramic
C6	100	ufd	10%	Sprague 150D 20v
C8	33	pf	5%	Silver Mica
*C9	.1	ufd	10%	Miniature Ceramic
*C10	.15	ufd	10%	Miniature Ceramic
C11	.0047	ufd	10%	Miniature Ceramic
C12	.047	ufd	10%	Sprague 192P 80v
C13	2.0	ufd	10%	TRW 50v
C14	.1	ufd	10%	Miniature Ceramic
C15	1.0	ufd	10%	TRW 50v
C16	10	ufd	10%	Sprague 150D 20v
C17	10	ufd	10%	Sprague 150D 20v
C18	101	ufd	10%	Miniature Ceramic
C19	.022	ufd	10%	Sprague 192P 80v
C20	330	pf	5%	Silver Mica
C21	.022	ufd	10%	Miniature Ceramic
C22	.022	ufd	10%	Miniature Ceramic
*C23	2000	pf	5%	Silver Mica
C24	.001	ufd	10%	Miniature Ceramic
C25	330	pf	5%	Silver Mica
C26	330	pf	5%	Silver Mica
C27	330	pf	5%	Silver Mica
C28	10	ufd	10%	Sprague 150D 20v
C29	10	ufd	10%	Sprague 150D 20v
C30	.0033	ufd	10%	Sprague 192P 200v
C31	10	pf	5%	Silver Mica
C32	10	pf	5%	Silver Mica
C33	10	pf	5%	Silver Mica
C34	10	pf	5%	Silver Mica

* $5KH_Z$ operation only:

C9 = .068 ufd 10% Miniature Ceramic
C10 = .1 ufd 10% Miniature Ceramic
C23 = 1330 pf 5% Silver Mica

Diodes

CR1	1N 914
CR2	1N 914

Inductors

L1	82 uh Nytronics Wee Ductors
L2	82 uh Nytronics Wee Ductors

Integrated Circuits

1C1	CD4023	Triple 3 Input NAND Gates
1C2	CD4023	Triple 3 Input NAND Gates
1C3	CD4023	Triple 3 Input NAND Gates
1C4	CD4023	Triple 3 Input NAND Gates
1C5	CD4049	Inverting Hex Buffer
1C6	CD4049	Inverting Hex Buffer
1C7	CD4021	Shift Register
1C8	CD4021	Shift Register
1C9	CD4015	Shift Register
1C10	CD4015	Shift Register
1C11	CD4019	Quad AND/OR Select Gates
1C12	CD4019	Quad AND/OR Select Gates
1C13	CD4017	Decade Counter
1C14	CD4017	Decade Counter
1C15	CD4017	Decade Counter
1C16	CD4017	Decade Counter
1C17	CD4013	Dual "D" type Flip-Flop
1C18	CD4015	Shift Register
1C19	CD4015	Shift Register
1C20	CD4012	Dual 4 Input NAND Gates
1C21	CD4012	Dual 4 Input NAND Gates
1C22	CD4050	Non-Inverting Hex Buffer
1C23	CD4025	Triple Input NOR Gates
1C24	CD4050	Non-Inverting Hex Buffer
1C25	CD4050	Non-Inverting Hex Buffer
1C26	CD4050	Non-Inverting Hex Buffer
1C27	CD4013	Dual "D" type Flip-Flop
1C28	CD4013	Dual "D" type Flip-Flop
1C29	CD4013	Dual "D" type Flip-Flop
1C30	CD4013	Dual "D" type Flip-Flop
1C31	uA749	Dual Operational Amplifier
1C32	uA749	Dual Operational Amplifier
1C33	uA749	Dual Operational Amplifier
1C34	7812	Regulator (12v)
1C35	7812	Regulator (12v)
1C36	7806	Regulator (6v)
1C37	NE566	Oscillator
1C38	uA777HC	Operational Amplifier

DECK UNIT DEMODULATOR

Resistors

¼ watt carbon 5% (unless noted)

R1	1	kilohm	
R2	33	kilohm	
R3	2.2	kilohm	
R4	220	kilohm	
R5	68	ohm	
R6	4.7	ohm	
R7	4.7	ohm	
R8	10	kilohm	
R9	10	kilohm	
R10	10	kilohm	
R11	33	ohm	
R12	10	kilohm	
R13	10	kilohm	
R14	10	kilohm	
R15	33	ohm	
R16	10	kilohm	
R17	47	kilohm	
R18	3.3	megohm	
R19	470	ohm	
R21	22	kilohm	
R22	3.9	kilohm	
R23	470	ohm	
R24	1.8	kilohm	
R25	1.8	kilohm	
R26	10	kilohm	
R27	10	kilohm	
R28	10	kilohm	
R29	33	ohm	
R30	1.8	kilohm	
R31	1.8	kilohm	
R32	10	kilohm	
R33	10	kilohm	
R34	10	kilohm	
R35	10	kilohm	
R36	33	ohm	
R37	10	kilohm	
R38	1.8	kilohm	
R39	1.8	kilohm	
R40	6.81	kilohm	RN60C Metal Film 1%
R41	10	kilohm	
R42	47	kilohm	
R43	5.6	kilohm	
R44	2.7	kilohm	
R45	2.2	kilohm	

Resistors (con't)

R46	2.2	kilohm
R47	150	ohm
R48	100	kilohm
R49	3.3	kilohm
R50	15	kilohm
R51	1.8	kilohm
R52	3.9	kilohm
R53	100	kilohm
R54	33	ohm
R55	100	ohm
R56	10	kilohm
R57	100	ohm
R58	1	kilohm
R59	10	kilohm
R60	100	kilohm
R61	10	kilohm
R62	1.8	kilohm

Sockets

12	Augat #514-AG-10D
18	Augat #516-AG-10D
1	Augat #508-AG-1-D

Terminal Post

12	Cambion #160-1043-03-01

Transistors

Q1	2N 2222
Q2	2N 4122
Q3	2N 5640
Q4	2N 5640
Q5	2N 5089
Q6	2N 5089
Q7	2N 2222
Q8	2N 3638a
Q9	2N 4122
Q10	2N 3566
Q11	2N 5640
Q12	2N 5640
Q13	2N 4122
Q14	2N 4122

DECK UNIT DEMODULATOR

HARDWARE

3	2/56 x ¼ Panhead Screws, SS
3	#2 Nuts, SS
3	#2 Flatwashers, SS
3	#2 Internal Tooth Lockwashers, SS
2	Ejectors w/pins

DECK UNIT

POWER SUPPLY

Circuit Board P/N 30028

Capacitors

C1 10 ufd Sprague 100v
C2 10 ufd Sprague 100v

Chokes

L1 .5H Triad #C-26-X

Diodes

CR1 1N752A

Hardware

2	#6 Hex Nuts
2	6/32 x 1/2 Pan Head Screws
2	#2153 Fiber Washers
2	#6 Internal Tooth Washers
4	#8 Star Lock Washers
2	#8 Flat Washers
4	8/32 x 1/4 Hex Standoffs, Threaded
2	#6 Flat Washers
4	8/32 x 3/8 Pan Head Screws

Resistors

R1 22 ohm 2 watt carbon 5%
R2 8.2 Kilohm 2 watt carbon 5%

Terminal Post

18 Cambion 140-1785-02-01-00

Thermistor

TH1 Fenwall #MB 13-L1

Transformers

T1 Triad #SP67
T2 Triad #SP29
T3 Triad #SP29

Transistors

Q1 2N5239 RCA

Potentiometer

P1 20 ohm #3339-P-1-200 Bourns

Switches

S1 #MSS-204NG-1 Alco

Heat Sink Hardware

1	43-03-2, Thermalloy Insulator
1	6016-B, Thermalloy

DECK UNIT CHASSIS PARTS LIST

MAIN CHASSIS

Front Panel #010-AL-02-0	1 each
Back Panel #011-AL-02-0	1 each
Chassis Rails #012-AL-02-0	4 each
Main Chassis #013-AL-02-0	1 each
Top Cover #015-AL-02-0	1 each
Bottom Cover #015-AL-02-0	1 each
Side Covers #014-AL-02-0	2 each
Output Connector Bracketts #016-AL-02-0	26 each
Screws #4/40 x 3/8, panhead	26 each
Nuts #4	38 each
Internal Lock Washers #4	38 each
Screws #4/40 x $\frac{1}{2}$, panhead	16 each
Filister head #4/40 x $\frac{1}{2}$	1 each
Screws #6/32 x 3/8, panhead	12 each
Nuts #6	12 each
Internal Lockwashers #6	12 each
Screws #8/32 x 3/8, panhead	8 each
Nuts #8	4 each
Internal Lockwashers #8	8 each
Screws #10/32 x 3/8, panhead	36 each
Internal Lockwashers #10	36 each
Screws #10/32 x $\frac{1}{2}$, panhead	2 each
Screws #$\frac{1}{4}$ x 28, flathead	4 each
Bezel #018-AL-02-0	1 each
Binding Post #111-0103-001	6 each
Capacitors, Mini, .33ufd	9 each
Handle Set #H-9113B	1 each
LED's #H-5082-4403	3 each
Plexi-Clips #017-AL-02-0	4 each
Plexi-Lens #010-PG-02-0	1 each
Potentiometers #RV4NAYSD102A, 1k	1 each
" #3862C-282-102A, 1k	1 each
" #3862C-282-103C, 10k	1 each
Knob #RB67-1SB-DCM, $\frac{1}{4}$"	1 each
" #RB67-1SB-DCM, 1/8"	7 each
Resistors 1/8 watt carbon, 3.3k	9 each
Mini Lamp #377	1 each
Mini Speaker #011-EL-02-0	1 each
Speaker Brackett #019-AL-02-0	1 each
Switch #JBT 1-2-3	3 each
" #JBT 2-2-3	2 each
Switch #PS-105	1 each
" #PS-107	1 each
" #9A45218N	3 each
" #PL106705	1 each
Mini Transformer #012-EL-02-0	1 each

DECK UNIT CHASSIS PARTS LIST

CHASSIS AND BACK PANEL

Guidespacers #T101 .200	4 each
" #T101 .250	20 each
" #T101 .500	12 each
" #T101 1.000	12 each
Guides #T101 301.60	8 each
Rails #T902 800	2 each
Connectors #8016-090-217-804	2 each
" #PT02a-12-8-s	2 each
" #PT02a-8-3-p	1 each
" #PT02a-8-4-s	1 each
Power Buss #	1 each
Power Supply #018-PC-02-0	1 each
" #B50FT20	1 each
" #213	1 each
Fuse Holder #HKP	1 each
Fuse #2A	1 each
Connectors #706-7015-01	8 each
	1 each
Connectors #8016-090-206-707	1 each

ACCESORIES

Connector #PT06a-8-3s (sr)	1 each
" #PT06a-8-4p (sr)	1 each
" #PT06a-12-8p (sr)	2 each
" 8016-090-296-707	1 each
Line Cord #17462s	1 each
Packing Crate	1 each
Packing	1 each
Operations Manual	1 each

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APPENDICES

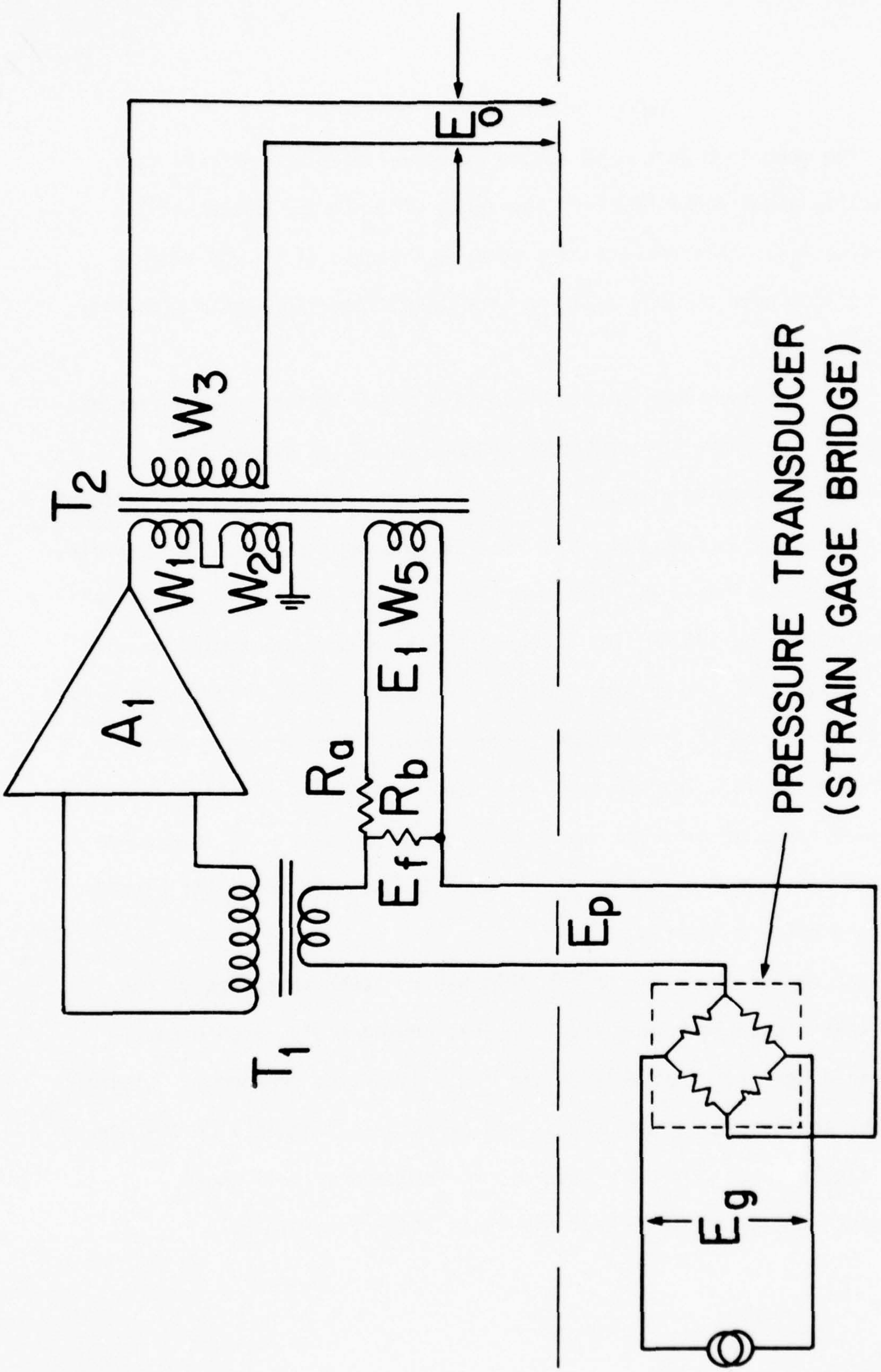
10kHz TUNED FEED-BACK AMPLIFIER

The open loop gain used in the pressure interface circuit is typically about 3,000,000 from the input of T_1 to the output of T_2 (winding W_3). This results in a feed-back factor of 30,000 (for closed loop gain of 100) ensuring excellent closed loop gain stability at $10kH_z$.

The high open-loop gain and high feed-back factor require careful design of the phase and amplitude response of A_1 if closed loop oscillation is to be avoided. It can be readily shown that conventional operational amplifiers cannot be used in this application. For example, if the open-loop gain at $10kH_z$ was 3,000,000 the unity gain frequency would have to be 300 MH_z for a conventional operational amplifier with 6 db/octave roll off (assuming close loop gain - 100). Clearly this is totally impractical, particularly when transformers are used at the input and output. Transformer T_1 is used to optimize signal to noise and as a means of avoiding common mode noise problems. T_2 is a tuned transformer (see Figure 7.1) and is used to optimize power efficiency and to provide a floating output.

The design approach used in this system takes advantage of the fact that closed loop gain accuracy and, consequently, high open-loop gain were required only at the fixed operating frequency. Clearly one can achieve very high gain at any particular frequency by the use of a single tuned circuit. However, at frequencies well above resonance the gain (A) of a single tuned stage is given by

Fig. 7.1



T₂
W₃
W₁
W₂
W₅
E₁
A₁
Rₐ
R_b
E_f
E_p
T₁
E_g
E_o
PRESSURE TRANSDUCER
(STRAIN GAGE BRIDGE)

$$A = \frac{F_r A_r}{QF}$$

where A_r = gain at resonance

F_r = resonant frequency

Q= quality factor of tuned circuit

F= frequency

For a feed back factor of 30,000 at resonance, the frequency (F_1) at which the feed-back factor reduces to unity, is calculated as follows:

$$\frac{A_r}{A} = 30,000$$

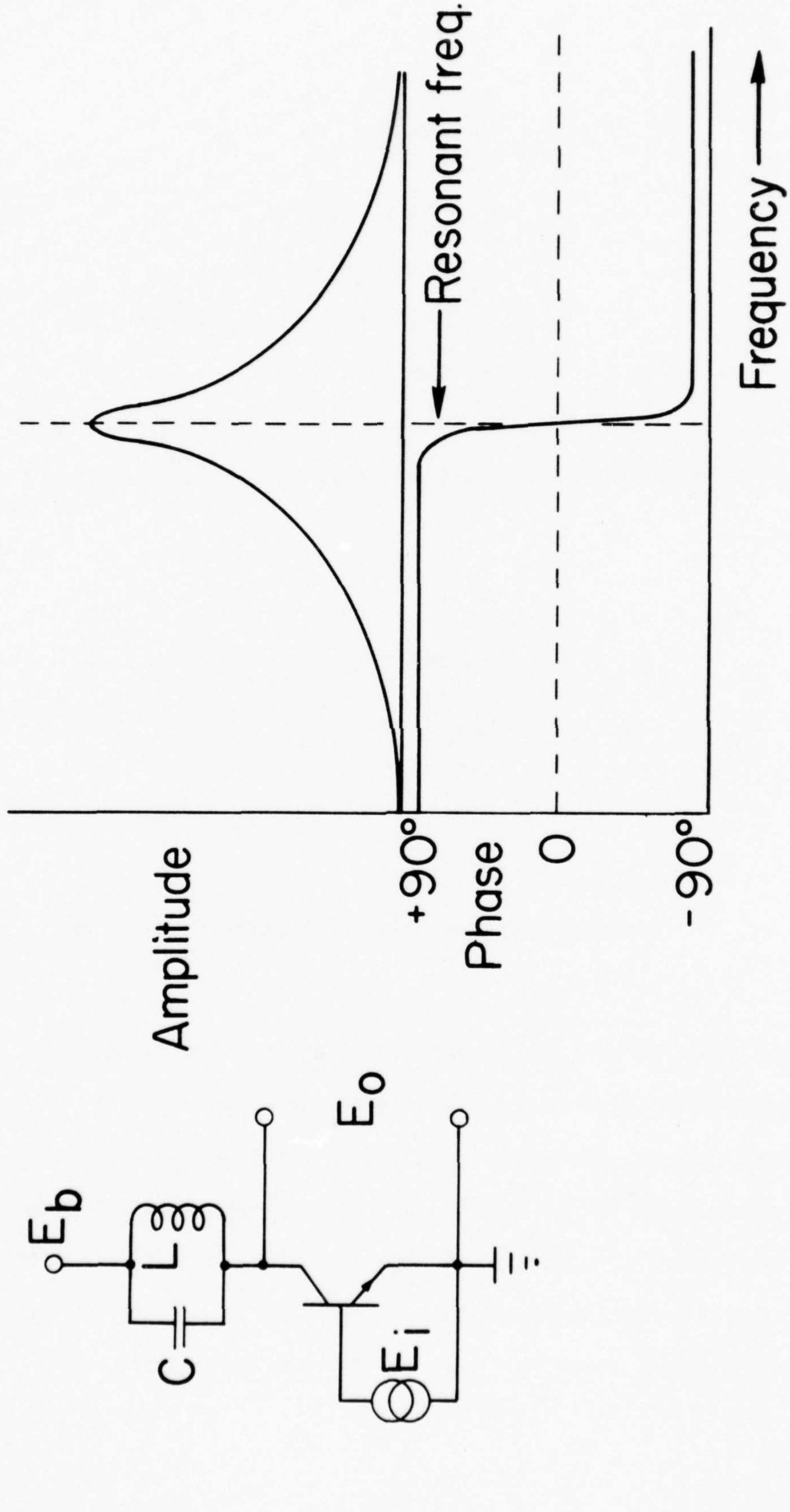
$$= \frac{QF_1}{F_r}$$

$$\text{therefore } F_1 = \frac{30,000F_r}{Q}$$

A typical value for Q is 50 therefore, F_1 = 6 MH_z

Since the tuned circuit has a phase shift approaching 90° at frequencies well above or below resonance (see Figure 7.1(2), the untuned stages, including input and output transformers, must have a total phase shift less than 90° for frequencies up to 6 MH_z if the amplifier is to be unconditionally stable under closed loop conditions; a difficult situation. If one were to cascade two tuned stages of the type shown in Figure 7.1(2), the phase shift would

Fig. 7.1(2)



rapidly approach 180° above and below resonance and would almost certainly be more difficult to stabilize under closed loop conditions than the single tuned stage circuit discussed above. However, a very simple modification to the circuit of Figure 7.1(2) readily permits the use of two tuned stages and is shown in igure 7.1(3) along with the amplitude and phase response. At resonance the impedance of the tuned circuit (L, C) is very high compared with R, consequently, R has negligible effects. However, at frequencies remote from resonance, L or C tends to be a short circuit leaving R as the dominant element. This has the advantage of very high gain at resonance and zero phase shift at very high or very low frequencies, thus permitting the use of an amplifier with two tuned stages.

Figure 7.1(4) shows a conceptual schematic of the feed-back amplifier without an input transformer. Fig. 7.1(5) lists the computed amplitude and phase response of this amplifier for both open-loop and closed-loop conditions with the following circuit values:

$gm_1 = gm_2 = 25\text{mA/Volt}$

$R_1 = 1{,}000$ ohms

$C_1 = C_2 = .01$ microfarads

$L_1 = L_2 = .0253303$ henries

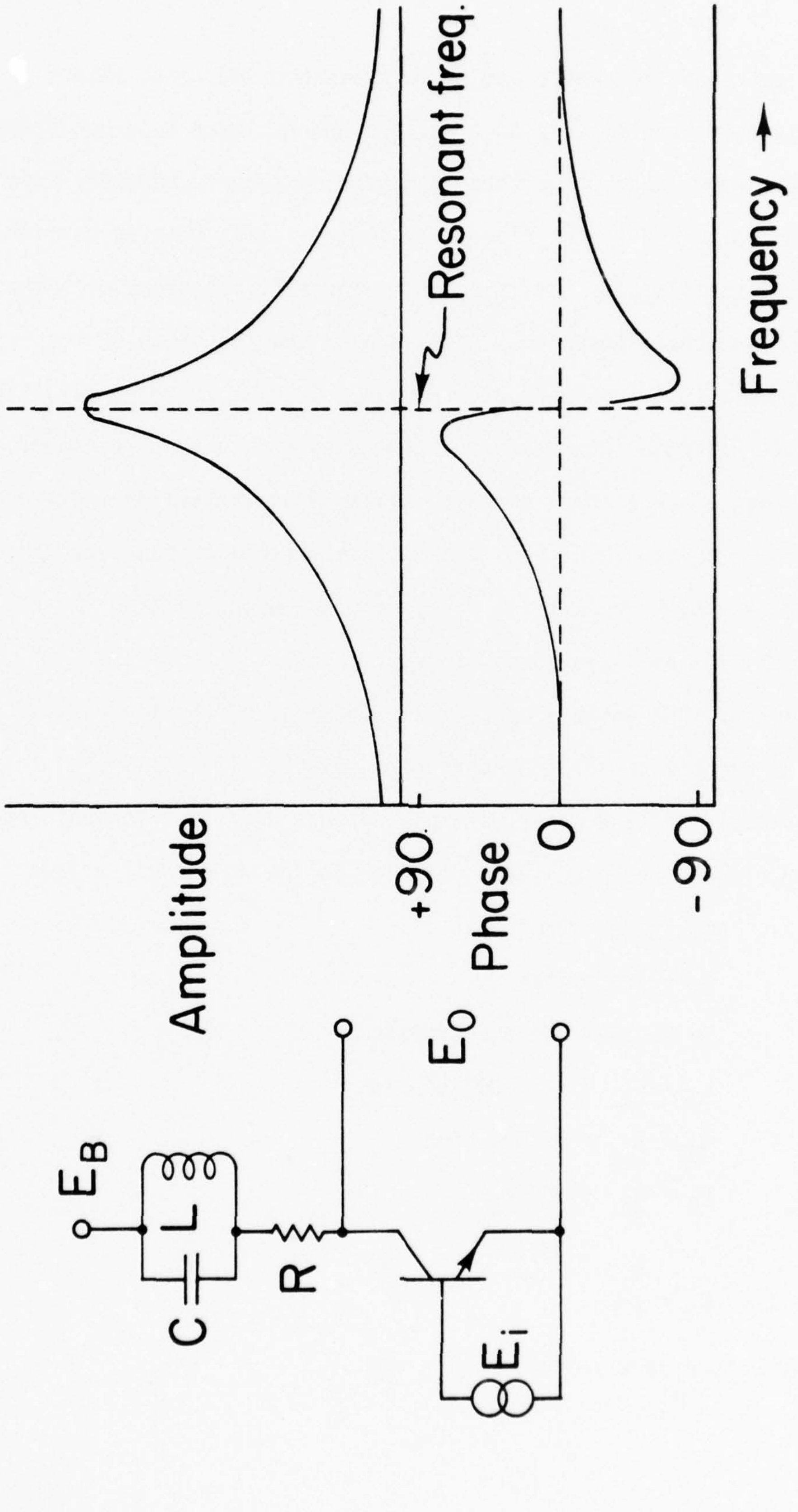
$R_2 = R_3 = 80{,}000$ ohms

$N_1 = N_2 = 100\ N_3$

i.e. $N_3 = \frac{N_1}{100}$

therefore, feed-back voltage $(E_f) = \frac{E_o}{100}$

Fig. 7.1(3)



An examination of Fig. 7.1(5) shows that for a closed loop gain of 100 at 10 kHz operation is quite stable with a 1 db peak at 3,500 and 28,000 Hz. Also, at extreme frequencies, i.e., 100 Hz and 1 MHz, the phase shift is almost down to 90° from a maximum of about 162°. The frequencies at which the open-loop gain is 100 are about 1,000 and 100,000 Hz, and the phase shifts are about +99° and -99° respectively. This means that if a transformer is placed at the input and is inside the loop, its phase shift must be small at 10 kHz and less than ±81° at 1,000 and 100,000 Hz. These are readily met permitting the use of transformers within the loop for the purpose of providing optinum signal to noise ratios and floating inputs.

The basic design shown in Figure 7.1(4) was used in the interface circuits for temperature, conductivity, and pressure.

Fig. 7.1(4)

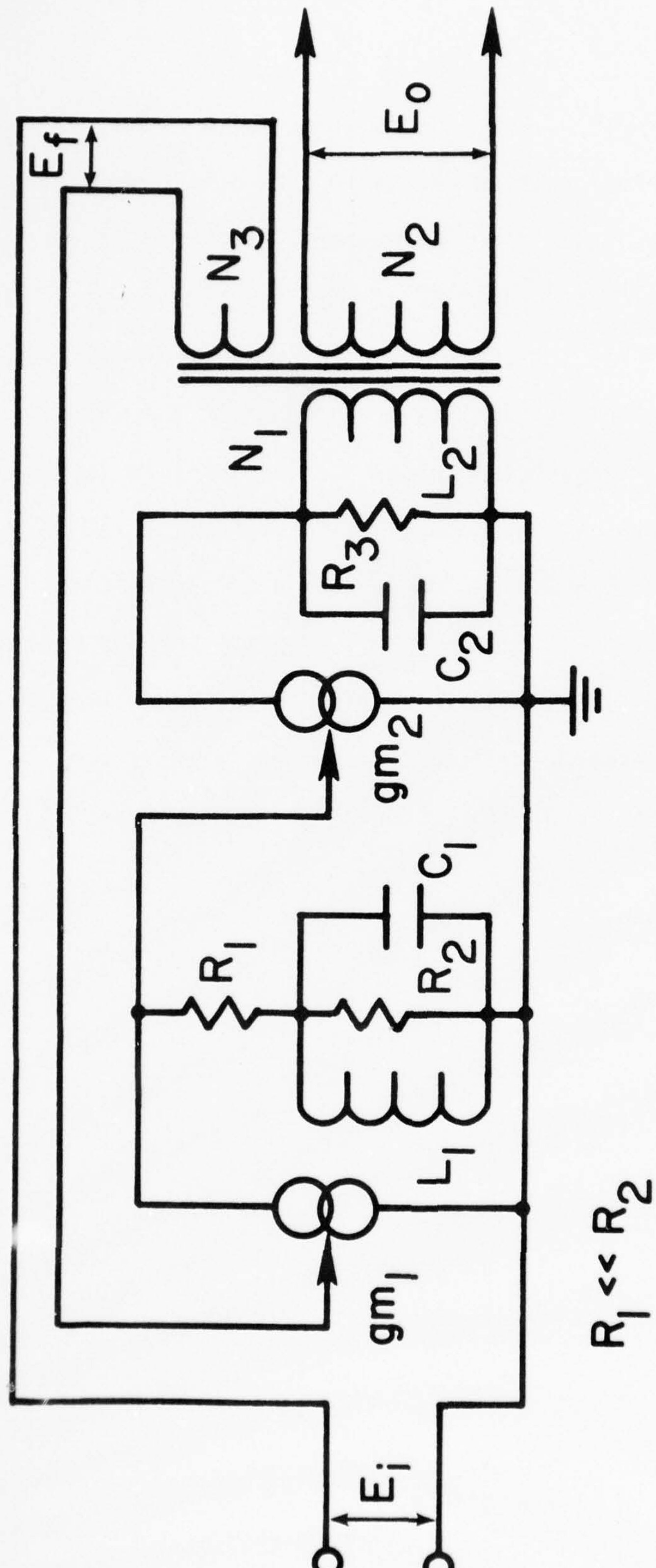


Fig. 7.1(5)

	OPEN LOOP PARAMETERS		CLOSED LOOP PARAMETERS	
Frequency (Hz)	Gain (db)	Phase (Deg)	Gain	Phase (Deg)
100	20.0	90.9	9.91595	85.21
200	26.0	91.8	19.6479	80.476
500	34.0	94.5	46.2133	67.071
1000	40.2	99.0	77.6821	48.909
2000	46.8	108.1	103.959	26.878
3000	51.4	117.2	110.024	15.276
3500	53.5	121.8	110.34	11.467
4000	55.5	126.4	109.818	8.513
5000	59.8	135.5	107.59	4.442
6000	64.6	144.4	104.986	2.076
8000	78.3	159.3	101.153	0.249
9000	91.1	161.8	100.265	.050
9500	103.3	154.4	100.061	.017
9800	118.0	126.1	100.007	.006
9840	121.0	115.5	100.004	.005
9880	124.3	100.2	100.001	.003
9920	127.8	77.3	99.9991	.002
9960	130.8	43.6	99.9979	.001
10000	132.1	0.0	99.9975	.000
10040	130.9	-43.5	99.9979	-.001
10080	127.8	-76.8	99.9991	-.002
10120	124.4	-99.5	100.001	-.003
10160	121.2	-114.7	100.004	-.005
10200	118.2	-125.3	100.007	-.006
10500	104.2	-153.5	100.055	-.016
11000	92.8	-161.3	100.217	-.042
12000	81.7	-161.0	100.781	-0.154
16000	65.9	-146.5	104.375	-1.676
20000	59.8	-135.5	107.59	-4.442
30000	52.8	-120.3	110.351	-12.629
60000	45.0	-105.1	98.728	-32.611
100000	40.2	-99.0	77.6821	-48.909
300000	30.4	-93.0	32.0513	-74.335
1000000	20.0	-90.9	9,91595	-85.21

SERVO BALANCED THERMISTOR BRIDGE

A simplified schematic of the servo balanced thermistor bridge is shown in figure 7.2. The bridge consists of the miniature high speed thermistor R_T (Fenwal Electronics - GC32SM2), a fixed resistor R_F and two windings (W_2 and W_3) on transformer T_1. The value of R_F is chosen so that the bridge output voltage (E_t) has minimum non-linearity over the range of 0 to 30°C. The input to the first amplifier A_1 is equal to the difference between E_t and the output (E_m) from the multiplier M_1.

The two inputs to M_1 are -

i) a 10 KH_z sine wave signal from W_4 on T_1

ii) a DC signal (E_c) from the output of the integrator (A_2, R and C).

The input to the integrator is the output of a second multiplier M_2(a phase sensitive detector). The reference signal to the multiplier is a 10 kH_z square wave in phase with the oscillator signal E_g driving the thermistor bridge and multiplier M_1. The relationships are as follows:

$$\text{Output voltage } E_o = e_o \sin \omega t$$

$$= E_1 A_1 = e_1 A_1 \sin \omega t \ldots\ldots \quad (1)$$

$$\text{where } E_1 = E_t - E_m$$

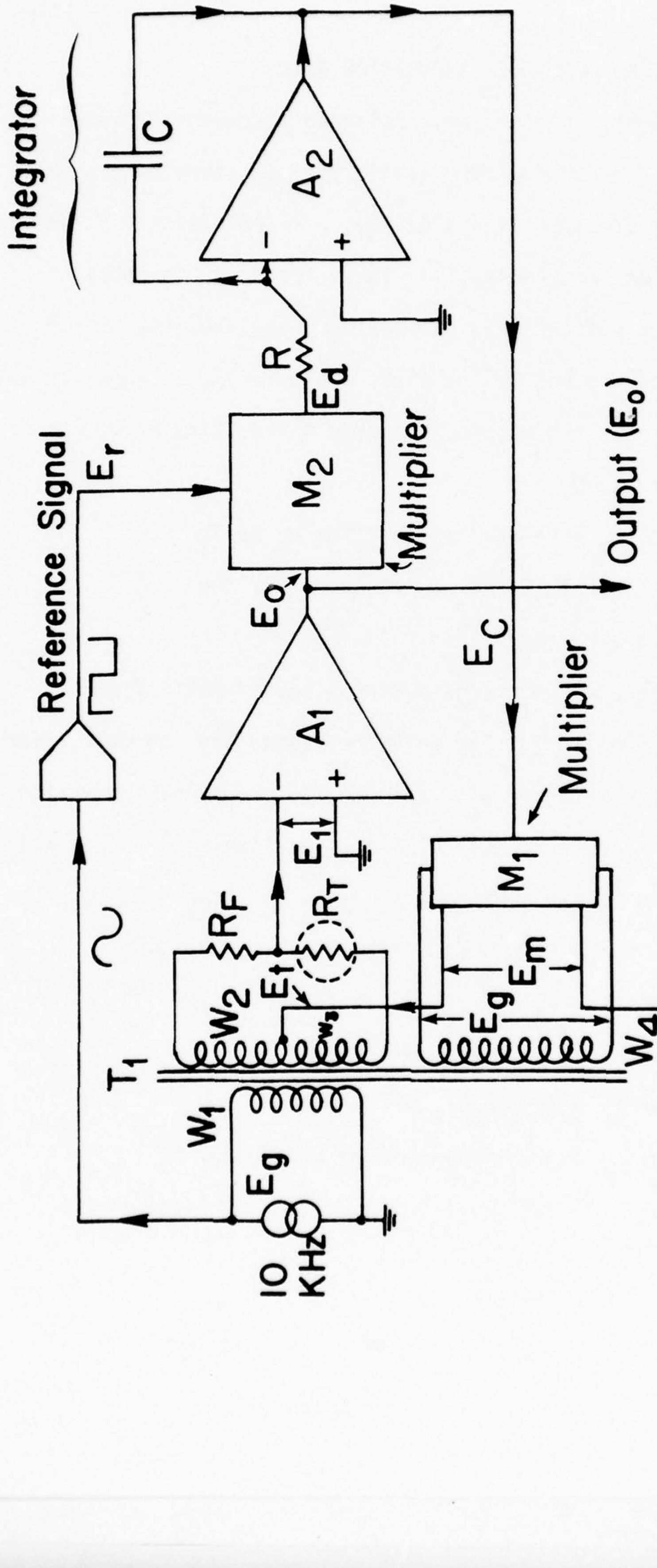
$$= (e_t - e_m) \sin \omega t$$

$$\text{now } E_m = K_1 E_c E_g$$

$$\text{where } K_1 = \text{scale constant of multiplier } M_1$$

$$\text{therefore } E_o = A_1(E_t - K_1 E_c E_g) \ldots\ldots \quad (2)$$

Fig. 7.2



R_T=Fast Response Thermistor

The output of the integrator E_c is given by

$$E_c = \frac{1}{RC}\int E_d \, dt$$

now $E_d = K_2 E_o E_r$

where K_2 = scale constant of multiplier M_2

Since E_r is a constant amplitude square wave in phase with E_i

we can express E_r as a Fourier series as follows:

$$E_r = \frac{4}{\pi} e_r (\sin \omega_t + \frac{1}{3} \sin 3\omega t + \ldots + \frac{1}{n} \sin n\omega t + \ldots)$$

.. (n = odd integer)

and e_r = peak amplitude of square wave

therefore $E_d = \frac{4}{\pi} e_r K_2 e_o \sin \omega t (\sin \omega t + \frac{1}{3} \sin 3 \omega t + \ldots \text{etc.})$

$= K_3 e_o (\sin^2 \omega t + \frac{1}{3} \sin \omega t \sin 3 \omega t + \ldots \text{etc.})$

where $K_3 = \frac{4}{\pi} K_2 E_r$ = *constant*

Since $\omega >>> \frac{1}{RC}$ only zero frequency components of E_d will cause a significant output (E_c) from the integrator

since $\sin^2 \omega t = \frac{1}{2}(1 - \cos 2\omega t)$ the only zero frequency component of E_d is given by

$$E_d = \frac{1}{2} K_3 E_o$$

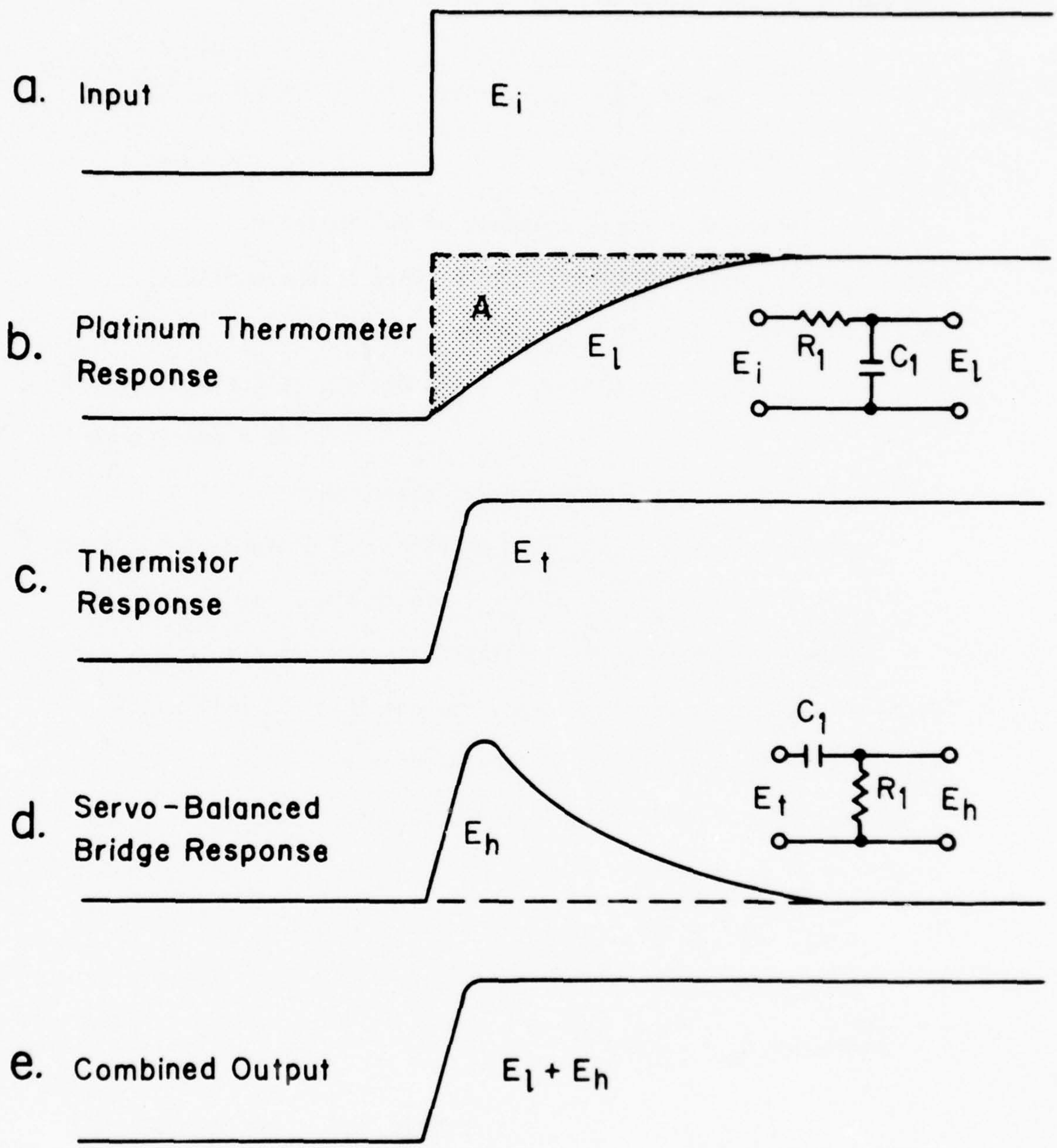
therefore $E_c = \frac{K_3}{2RC}\int E_o \, dt$

substituting in (2) $E_o = A_1 (E_t - \frac{K_1 E_g K_3}{2RC}\int E_o \, dt)$

$$= A_1 E_t - \frac{K}{RC}\int E_o \, dt \; \ldots\ldots \quad (3)$$

where $K = A_1 K_1 K_3 E_g$ = constant.

Fig. 7.2(2)


a. Input
E_i
b. Platinum Thermometer Response
A
E_l
E_i
R_1
C_1
E_l
c. Thermistor Response
E_t
d. Servo-Balanced Bridge Response
C_1
E_t
R_1
E_h
E_h
e. Combined Output
$E_l + E_h$

The simple high pass filter in Fig 7.2(2) has the following response

$$E_h = E_i - \frac{1}{R_1 C_1}\int E_h \, dt$$

if we make $E_i = A_1 E_t$

and $R_1 C_1 = \frac{RC}{K}$

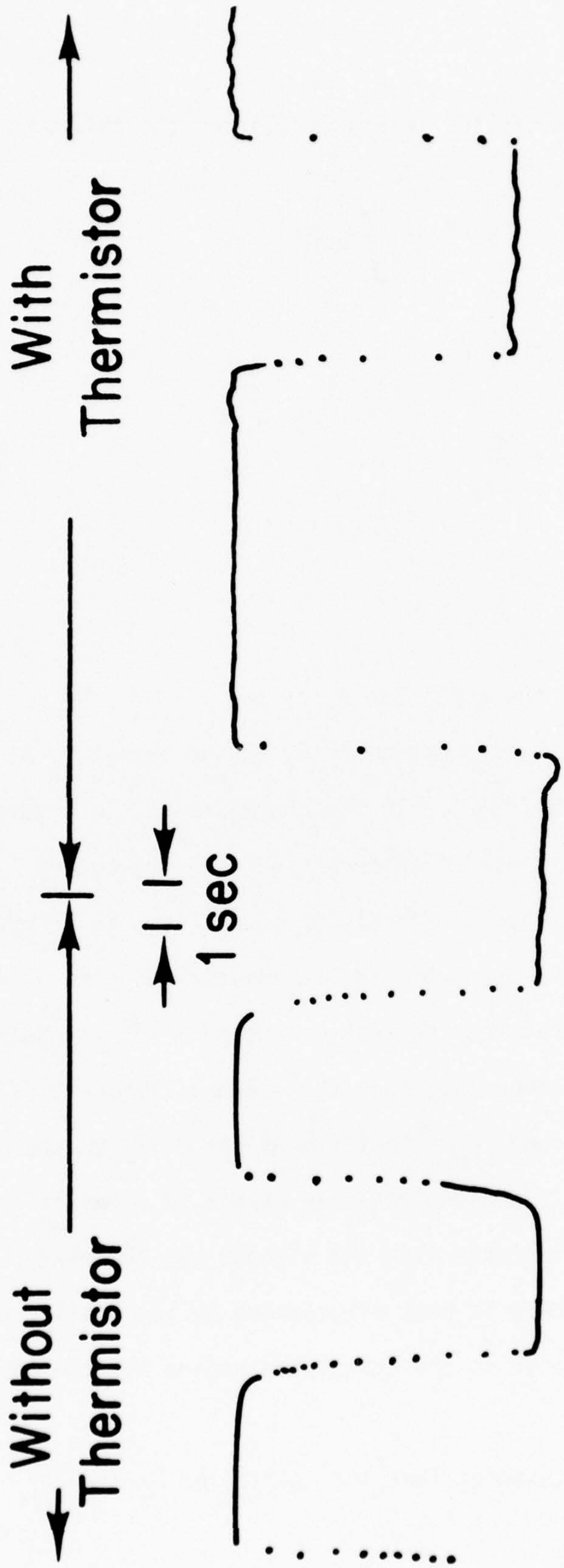
then $E_h = E_o$

This means that the amplitude e_o of the 10 KH_z sine wave output E_o has the same response to a change in E_t as the output E_h of the high pass filter shown in 7.2(2). If the thermistor R_T in Figure 7.2 had an instantaneous response to temperature, then the output E_o would provide exactly the correct signal to correct the lag error in the platinum thermometer. However, the thermistor response is not instantaneous. Therefore, the combined response of the platinum thermometer and the thermistor has the speed of response of the thermistor and the long term stability of the platinum thermometer.

The response to a temperature step change is shown in Figure 7.2(3); the figure shows data taken with and without the thermistor. The improvement in response is best illustrated by the smaller number of data points which occur in the transition region for the combined measurement.

This discussion assumes that the multiplier M_2 and the integrator

Fig. 7.2(3)



are ideal devices, and that E_d is zero when E_o is zero and the integrator offset voltage is zero. Adequate performance in the integrator is achieved using a state of the art integrated circuit operational amplifier, such as a National Semiconductor LM208A. The multiplier M_2 is implemented using a switching type synchronous detector. The output (E_o) of A_1 is applied to the primary of a transformer with a center-tapped secondary, the center tap being grounded. FET's connected to each side of the secondary are synchronously turn "on" and "off" by E_r and its complement, resulting in full wave synchronous detection with excellent quadrature rejection and essentially zero dc output when E_o is zero.

The time constant of the loop is given by

$$t = \frac{T}{A_o}$$

where $T = RC$ (Ref. Figure 7.2(2)

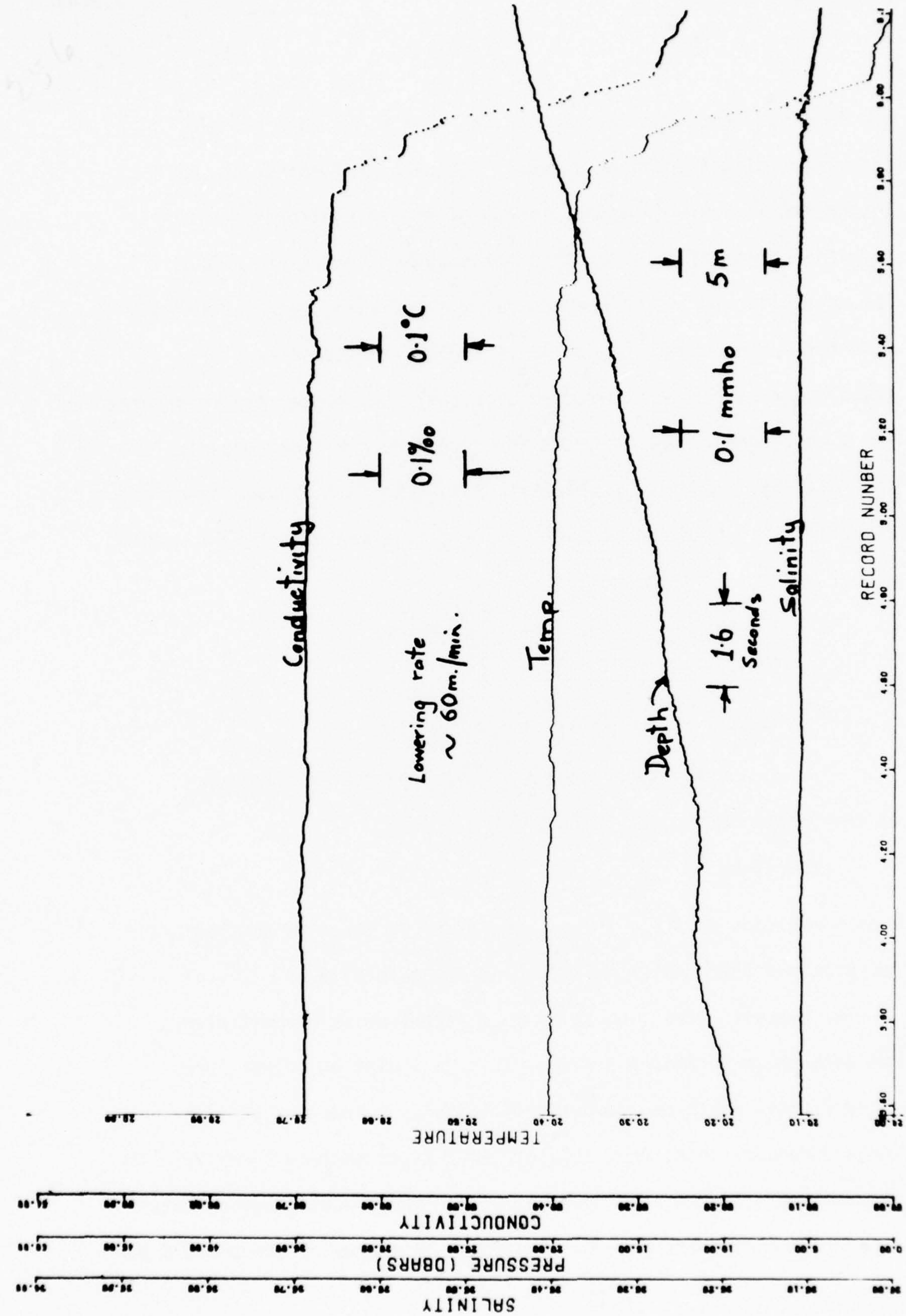
and A_o = open-loop gain measured from the output of the integrator to the output of M_2

therefore $t = \frac{RC}{A_o}$

Then servo time constant (t) is made equal to the time constant of the platinum thermometer by adjusting the gain of A_1.

The overall effectiveness of this technique is demonstrated by the data shown in Figure 7.2(4). This is a plot of temperature, conductivity, depth and computed salinity as a function of time (record number) going from a fairly well mixed surface layer into the thermocline. In the high gradient region individual readings taken 30 milliseconds apart show maximum rates of change of about 0.6°C per

Fig. 7.2(4)



Conductivity
Temp.
Depth
Salinity
Lowering rate ~ 60m./min.
0·1‰
0·1°C
0·1 mmho
5m
1·6 Seconds
RECORD NUMBER
TEMPERATURE
CONDUCTIVITY
PRESSURE (DBARS)
SALINITY

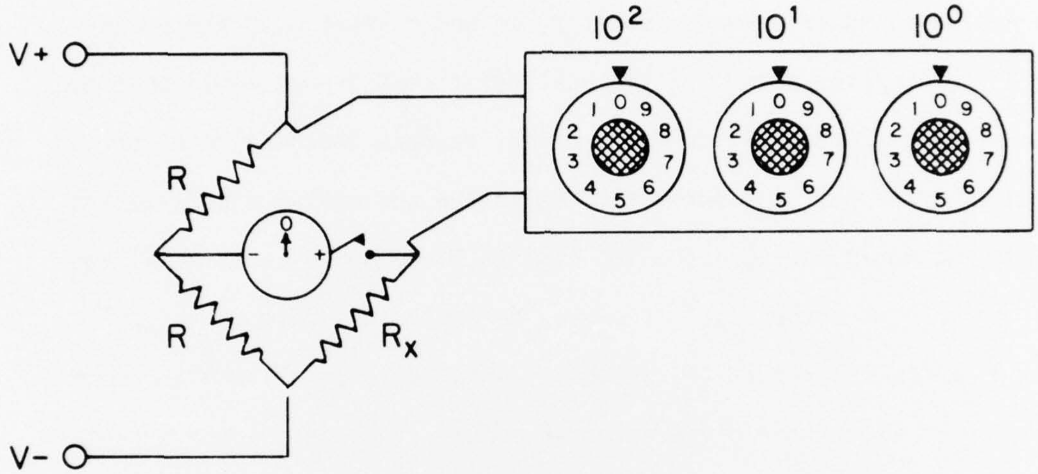
second with corresponding salinity "spikes" less than 0.01 ppt. This clearly shows the match between the response time of the conductivity sensor and the combined response of the thermistor and platinum thermometer.

A SUCCESSIVE APPROXIMATION METHOD

This is a very common method for comparing a switch selectable value with an unknown value. If we had a wheatstone bridge with a decade resistor and an unknown resistor, we would start with the decade box at zero, zero, zero. If the null meter read "+" we would continue, if, however, it read "-" we would either reverse the null meter or the drive (to make the sign correct). Using the successive approximation method, we would now turn the 10^2 dial to 9 and decrease it until the null meter read either null or plus. We could then move to the 10^1 and 10^0 knobs and repeat the process. This would permit a 0.1% determination of Rx. If the differences were small, we would spend a longer time arriving at a decision than if they were large, similarly after a very large error signal we would allow the null meter time to settle before pressing the sample switch again (in the CTD the adaptive sampling board determines the sample time and recovery time necessary for proper operation, and the comparator replaces the null meter.)

The digitizer logic board may be considered as seventeen D type flip-flops. All of their D inputs are connected in common (to the comparator output). The stages are sequentially clocked and the 'clock' of each stage is connected to the 'set' of the next stage. Q_0 is connected to a switch capable of reversing the polarity of the sensor output whilst each of the other 16 Q outputs is connected to single pole change-over switch on the digital to analog converter board. Each of these switches controls a voltage equivalent to its weight in the binary

Fig. 7.3



code, i.e. Switch 1 only turned on causes the D/A output to be equal to half full scale $\left(\frac{2^{15}}{2^{16}-1}\right) \times FS = \frac{1}{2}FS$

Switch 16 only turned on causes the D/A output to be equal to one least significant bit $\left(\frac{2^{0}}{2^{16}-1}\right) \times FS = \frac{1}{65,535}\ FS$

while switch 1 and switch 16 both turned on causes a D/A output equal to the algebraic sum of the above

$$= \frac{FS}{2} + \frac{FS}{65,535}$$

SALINITY COMPUTATION

Because absolute conductivity is difficult to measure most investigators have worked with conductivity ratio using standard sea water as a reference. Consequently, the salinity computation goes as follows:

$$G = G_i\ (1 - \alpha(T\text{-}15) + \frac{1}{3}\ KP)$$

where G = conductivity corrected for the effect of temperature and pressure on the conductivity cell.

G_1 = indicated conductivity

The CTD is calibrated against the 1968 I.P.T.S. and the following equations require that temperature according to the 1948 I.P.T.S. be used. The following equation will implement this conversion.

$$T_{48} = T_{68} + 4.4 \times 10^{-6}\ T_{68}\ (100 - T_{68})$$

α = coefficient of linear expansion (of alumina)

$\alpha = 6.5 \times 10^{-6}\ {}^{o}C^{-1}$

T = temperature (1948 I.P.T.S.)

K = bulk modulus of compressibility (of alumina)

$K = 1.5 \times 10^{-8}$ cm/cm/decibar

P = pressure (decibars)

$$R_T = \frac{G}{G_o p(T) R_p(T,P,S)}$$

where R_T = ratio of conductivity of sample to conductivity of 35 ppt when both are at temperature T and pressure P

G_o = conductivity of 35 ppt sea water at 15^oC (P=0)

$p(T)$ = ratio of conductivity of 35 ppt sea water at temperature T to its conductivity at 15^oC (P=0)

Brown in 1966 determined the ratio as follows:

$$p(T) = .676524 + .201317\times10^{-1}T + .998866\times10^{-4}T^2$$

$$-.194260\times10^{-6}T^3 - .672491\times10^{-8}T^4$$

Bradshaw and Schleicher in 1965 determined the effect of pressure on conductivity as follows:

$$R_p(T,P,S) = 1 + .01(g(T)f(P) + h(P)j(T)) (1 + \ell(T)m(S))$$

where $g(T) = 1.5192 - 4.5302\times10^{-2}T + 8.3089\times10^{-4}T^2$
$-7.900\times10^{-6}T^3$

$$f(P) = 1.04200\times10^{-3}P - 3.3913\times10^{-8}P^2 + 3.300\times10^{-13}P^3$$

$$h(P) = 4 \times 10^{-4} + 2.577\times10^{-5}P - 2.492\times10^{-9}P^2$$

$$J(T) = 1.00 - 1.535\times10^{-1}T + 8.276\times10^{-3}T^2 - 1.657\times10^{-4}T^3$$

$$\ell(T) = 6.95\times10^{-3} - 7.6\times10^{-5}T$$

$$m(S) = 35.000 - S$$

where S = salinity (ppt)

The salinity dependence of R_p is quite small so that for continuous profiling the value of S computed for the previous scan is quite adequate.

$$R = R_T + (1-R_T)\,(.0175R_T - .0045R_T{}^2)\,(1 - .08T + .00089T^2)$$

where R = ratio of conductivity of sample to conductivity of 35 ppt sea water when both are 15°C and atmospheric pressure.

lastly $S = .7347 + 32.2807R + 3.4775R^2 - .02395R^3$

The last two relationships were derived from data published by Brown in 1966.

PHASE LOCKED LOOP

The principal element of the CTD demodulator is a phase-locked loop which is illustrated in a generalized form in Fig. 7.5. The phase of the frequency, f of an input signal is compared with the divided output frequency f' of a Voltage Controlled Oscillator (V.C.O.,), producing the dc signal which is the V.C.O. input. The loop "locks" when f' is 90° phase-shifted with respect to f. The data transmission clock is generated in the underwater unit and regenerated from the telemetred data by means of a phase lock loop circuit in the deck unit.

SYNCHRONOUS DETECTOR

The deck unit phase comparator and filter comprise a phase-sensitive detector and an integrator. The phase-sensitive detector is illustrated in Fig. 7.5(2) below. When Z is high, the detector is a unity gain inverting amplifier; when Z is low, the detector is a unity gain non-inverting amplifier. The truth table for this device will be:

The wave forms in Figure 7.5(3) illustrate the performance of the detector with three differently phased input signals, W_1 thru W_3.

If the chopper and unknown signal are in phase, a negative output is produced; if they are in anti-phase, a positive output is produced. Finally if the signals are in quadrature (90° phase shifted,) then the output will average zero volts d.c.

Fig. 7.5

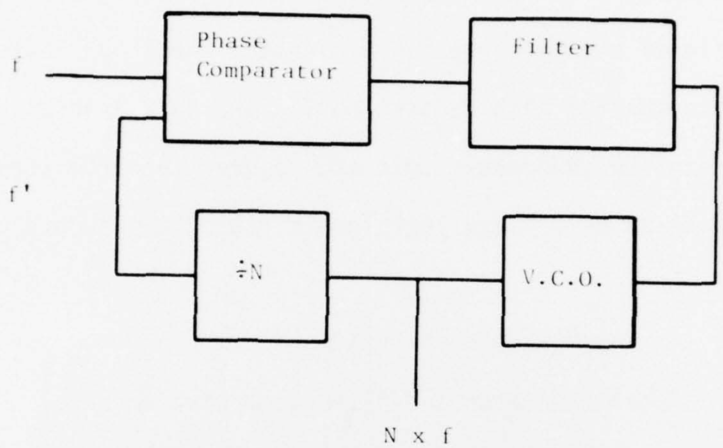


Fig. 7.5(2)

Z	W	X
1	W	$\bar{W}$
O	W	W

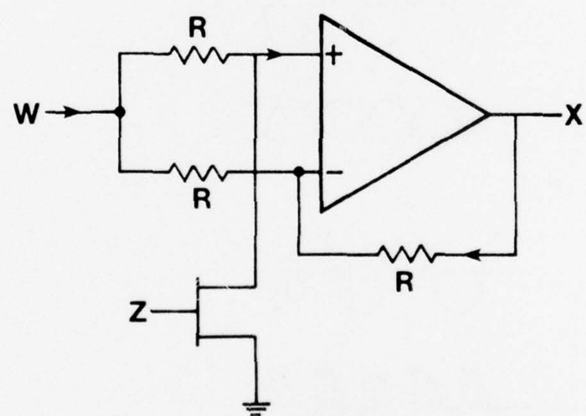
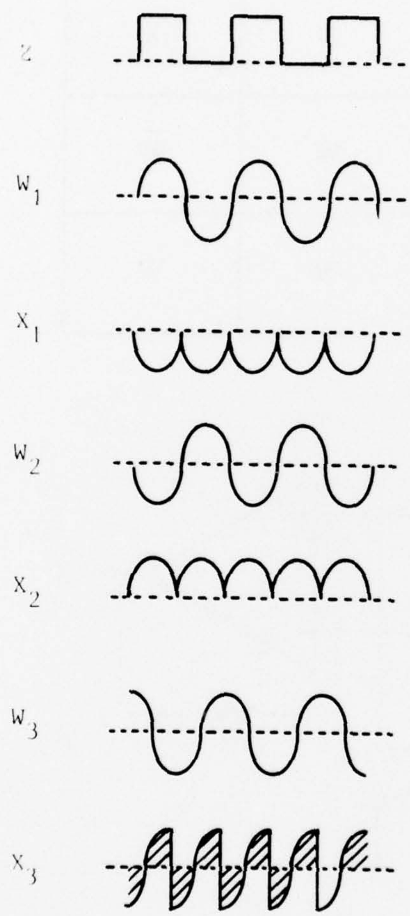


Fig. 7.5(3)



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A Conductivity, Temperature and Depth (CTD) profiler has been designed to make precise fine scale measurements of these physical parameters in the ocean. This CTD system consists of a shipboard Data Terminal deck unit and an underwater unit which provides continuous sampling of the three variables as it is lowered into the water. Additional sensors can be added to measure other variables; the most common is dissolved oxygen. → over

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This report is a detailed description of the CTD System and includes the necessary documentation to operate and maintain the equipment.